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R.H. SAUNDERS GS INVESTIGATION

Report No 91-132-K

R.H.K. Tsang
Engineer
Soil Sciences Section
Civil Research Department

ABSTRACT

A detailed investigation at R.H. Saunders GS, Unit 4 was performed. Numerous instruments were installed and monitored during the load testing phase. The details of the instrumentation and data collected so far are reported. Conclusions and recommendations are made regarding further studies.

job	file	date	report no.
43-267-481	843.4	July 8, 1991	91-132-K

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To Dr. C.F. Lee
Manager
Civil Engineering and Architecture Department
Design and Development Division - Generation

Attn: Mr. J.H.K. Tang/Dr. A. Danay

R.H. SAUNDERS GS INVESTIGATION

1.0 INTRODUCTION

At the request of Dr. A. Danay of the Civil Engineering and Architecture Department, an investigation was proposed for Unit 4 at R.H. Saunders GS. The investigation was conducted by the Soil Sciences Section, Civil Research Department from November 1990 to February 1991. Subsequently, in March 1991, a load testing and monitoring program was performed.

The investigation performed by the Soil Sciences Section is part of a major study undertaken by the Civil Engineering and Architecture Department to determine/assess the problems encountered at R.H. Saunders GS.

The purpose of this study, performed by the Soil Sciences Section, was to fabricate and install various instruments; to monitor some of these instruments during the load testing phase (March 1 to 10/91); and to collect long-term data throughout the year of 1991.

This report summarizes the details and results of the completed study to this point in time. Long-term monitoring has been cancelled from this study due to cost constraints.

2.0 SCOPE OF INVESTIGATION

The investigation performed by the Soil Sciences Section consisted of installing and/or monitoring the following instrumentation:

(A) pendulums (Qty = 3)
(b) vibrating wire extensometers (Qty = 2)
(C) forced centering plates (Qty = 10)
(D) elevation stations (Qty = 21)
(E) Psion tiltmeters (Qty = 2)
(F) survey monuments (Qty = 5)

(G) Huggenberger crack gauges (Qty = 32)
(H) tape extensometer (Qty = 8)
(I) thermocouples monitored manually during load testing on Level S4

A summary in Table I identifies the location and identification name of each instrument installed, and subsequently monitored.

3.0 SITE LAYOUT AND CONDITION

3.1 Site Layout and Condition

There are sixteen turbine units at R.H. Saunders GS (Figure 1). A plan and cross-section of R.H. Saunders GS is depicted in Figure 2. The locations of normal and inverse pendulums, and survey monuments on the headworks is also depicted. Figures 3 and 4 show some of the instruments installed near Unit 4 in plan-view on Level S1, and in cross-section on Levels S2, S3 and S4. Figure 5 shows a brass survey elevation target mounted into the wall on Level S1, near the normal pendulum to monitor dam movements. Figures 6 to 8 show the extensive cracking and concrete movements observed through the structure. Figure 9 shows the formation of calcareous precipitate on Level S4 in the inspection tunnel.

Figure 10 shows, at Robert Moses GS, New York Power Authority, the difference in concrete cracking observed compared to R.H. Saunders GS.

After the installation of instruments, a scheduled shutdown of Unit 4 was performed. The operator's log book recorded the details of the events/activities during March 1 to 10, 1991 (Appendix A). During this period, all the instruments were monitored on a frequent basis, both manually or automatically by data loggers. The Soil Sciences Section participated during this load testing phase and the results of this monitoring are reported.

3.2 Pendulums

A cross-section of the pendulum locations in relation to the generating station and relative to Unit 4 are depicted in Figures 11 and 12 respectively. Figures 13 and 14 show previously installed pendulums for Unit 6 and Unit 12 monitored on a long-term basis.

3.2.1 Installation of Pendulums

Three pendulums were installed in the vicinity of Unit 4, as follows: normal pendulum through the headworks to inspection tunnel, inverse pendulum from Level S1 into bedrock, and normal pendulum in the stairwell (Figures 15 and 16). The drill logs and borehole alignment corrections for the normal (headworks) and inverse pendulums for Unit 4 are contained in Appendix B. Difficulties were initially encountered for the normal pendulum borehole drilled through the headworks. As a result, the initial NQ borehole

was abandoned and grouted. Another NQ borehole was installed and an inclinometer casing was grouted in the hole. Inclinometer readings were taken by the Dam Safety, Civil Maintenance Department for comparison with autocentering readings taken by the Soil Sciences Section, Civil Research Department

3.2.2 Normal Pendulum Readings

Pendulum readings being taken by the Soil Sciences Section are shown in Figure 17. Pendulum table readings were taken during the load testing phase (March 1 to March 10, 1991). Tables II to V summarize the results obtained from the numerous pendulums monitored on site.

Difficulties were encountered while taking autocentering readings for the normal pendulum (19 +03), Unit 4. Table VI summarizes the autocentering corrections and problems encountered. The corrected autocentering readings for Unit 4 normal pendulum (19 + 03) is summarized in Table VII. The individual sets of autocentering readings taken for limit 4 normal pendulum (19 + 03) are contained in Appendix C.

3.2.3 Inverse Pendulum Readings

During load testing, inverse pendulum table readings and autocentering readings were taken at Unit 4, inverse pendulum (19 + 77.5). Tables VIII and IX summarize the respective pendulum table readings and autocentering readings taken. The individual sets of autocentering readings taken are contained in Appendix D.

3.3 Vibrating Wire Extensometers

Two vibrating wire extensometers (WVWE1 and EVWE2) were installed on Level S4, Unit 4 (Figure 19). They are used to measure movements across the generator room (Figure 3). The results of the monitoring to-date are summarized in Table X.

3.4 Survey Stations

3.4.1 Survey Monuments and Elevation Stations

Figure 2 shows the location of the survey monuments installed along the crest of the dam. Figures 3 to 5 depict the locations of the elevation survey stations mounted throughout the generating station.

The survey monuments and elevation stations are monitored and reported on a long-term basis by the Civil Maintenance Department.

3.4.2 Forced Centering Plates

A plan view schematic shows the locations of the force centering plates used for accurate distance survey readings on Level S4 (Figure 20). A detailed schematic of the force centering plate is depicted in Figure 21.

Figure 22 shows the Tellurometer MA2000 mounted onto the force centering plates. The survey results are reported by the Civil Maintenance Department.

3.5 Psion Tiltmeters

Two Psion tiltmeters were installed on Level S4, on opposite sides (east and west) of Unit 4 on the upstream side. Figures 23 and 24 show the details of the installation procedure by the Soil Sciences Section. The data was recorded manually and automatically during the load testing phase. The Civil Maintenance Department documented these data readings.

3.6 Huggenberger Crack Gauges

Figures 25 and 26 show the Huggenberger crack gauges installed by the Soil Sciences Section. The crack gauges were monitored and reported by the Civil Maintenance Department. The initial readings recorded by the Soil Sciences Section are contained in Appendix E, which is documented for completeness.

3.7 Thermocouples

Numerous thermocouples were installed by the Concrete Technology Section, Civil Research Department, throughout the generating station (Table I). Manual temperature readings were taken by the Soil Sciences Section for those located on Level S4, Unit 4 (upstream-side) during the load testing phase (Table XI). Automated temperature readings, including strain gauges, were taken by the University of Toronto and the Mechanical Research Department.

3.8 Tape Extensometers

Tape extensometers were installed on Level S1, Unit 4 in the equipment and cable galleries by the Soil Sciences Section (Figure 3). The tape extensometers were measured and reported by the Rock Sciences Section, Civil Research Department.

4.0 CONCLUSIONS

Many instruments were installed by the Soil Sciences Section to monitor Unit 4 at R.H. Saunders GS. The details related to method of installation, locations, identification, etc are reported. During the load testing phase, the Soil Sciences Section along with other

sections and departments monitored several instruments. The data collected from the pendulums, vibrating wire extensometers, Huggenberger crack gauges and thermocouples are documented in this report.

5.0 RECOMMENDATIONS

(1) A detailed analysis and review of all the data collected during the load testing phase is required.

(2) Long-term monitoring of the instruments is necessary to establish seasonal and/or other operational trends at the site. In particular, pendulums at Unit 4 compared with the observed behaviour at Units 6 and 12.

(3) Routine maintenance and inspection of the instruments is necessary to ensure high quality data.

(4) Effective management of the database is required to access, to update, and to process the data collected for analysis.

ACKNOWLEDGEMENTS

Mr. E.M. Dobrowolski and staff at R.H. Saunders GS and Mr. D.A. McKay, Rock Sciences Section, Civil Research Department are acknowledged for their assistance and coordinating efforts. Mr. A.G. Morton and Mr. B.S. Mackey, Soil Sciences Section are appreciated for their significant contributions under strenuous constraints. The cooperation and support from the Civil Engineering and Architecture Department, R.H. Saunders GS, Civil Maintenance Department, Mechanical Research Department, and Civil Research Department are valued by the author.

Approved by:

J.B. Brown
Manager
Civil Research Department

Prepared by:

R.H.K. Tsang
Engineer
Soil Sciences Section

Reviewed by:

T.J. Carmichael
Supervising Engineer
Soil Sciences Section

RHKT:LM

TABLE I

R.H. SAUNDERS GS
Summary of Instrumentation Program Unit 4 - 90/91

(A) PENDULUMS (Qty = 3)

(1) NORMAL - Inspection tunnel CH 19+03 Deck to S4
(2) NORMAL - Unit 4 stairwell CH 19+77'6 S1 to S4
(3) INVERSE - S4 gallery CH 19+77'6 S1 to Elevation 90'

(B) VIBRATING WIRE EXTENSOMETERS (Qty = 2)

(1) WVWE1 - West side Unit 4 N/S across generator level ~ 190' elevation
(2) EVWE2 - East side Unit 4 N/S across generator level ~ 190' elevation

(C) FORCED CENTERING PLATE LOCATIONS ON S4 LEVEL (Qty = 10)

- installed on C of unit

US is inspection tunnel
DS is downstream tunnel

U1 US	U1 DS
U4 US	U4 DS
U6 US	U6 DS
U12 US	U12 DS
U16 US	U16 DS

D/S stations installed 7' above S4 fin. flr. 137'0
U/S stations installed 3'6 above Sr fin. flr. 129'6

(D) ELEVATION STATIONS (Qty = 21)

(1)	Level S1	WLP6 upstream wall near Unit 4, 180 elevation
(2)	Level S1	WLP5 south edge of step between 180 & 174 elevation, near Unit 5
(3)	Level S1	West side of column, 174 elevation, Unit 5
(4)	Level S1	East side of column, 174 elevation, near Unit 5
(5)	Level S1	WLP2 south wall 174 elevation, Unit 5
(6)	Level S1	WLP1 south wall 174 elevation, Unit 4, west side
(7)	Level S1	ELP12 South wall 174 elevation, Unit 4, east side
(8)	Level S1	ELP11 South wall 174 elevation, Unit 3
(9)	Level S1	ELP10 South side column, 174 elevation, Unit 3
(10)	Level S1	ELP9 South side column, 174 elevation, Unit 4

(D) ELEVATION STATIONS (cont'd)

(11)	Level S1	ELP8	South edge of step between 180 & 174 elevation, near near Unit 3
(12)	Level S1	ELP7	Upstream wall near Unit 3, 180 elevation
(13)	Level S2	Rdg Table	Ball brg on surface, west side Unit 4, D/S wall
(14)	Level S2	CLP22	℄ Unit 4, D/S wall
(15)	Level S2	ELP23	East side Unit 4, D/S wall
(16)	Level S3	Rdg Table	Ball brg on surface, west side Unit 4, D/S wall
(17)	Level S3	CLP32	℄ Unit 4, D/S wall
(18)	Level S3	ELP33	East side Unit 4, D/S wall
(19)	Level S4	Rdg Table	Ball brg on surface, west side Unit 4, D/S wall
(20)	Level S4	CLP42	℄ Unit 4, D/S wall
(21)	Level S4	ELP43	East side Unit 4, D/S wall

(E) PSION TILTMETERS (Qty = 2)

(1) WTM1 - West side Unit 4, 180 elevation, east side of column
(2) ETM2 - East side Unit 4, 180 elevation, west side of column

(F) SURVEY MONUMENTS (Qty = 5)

(1) Deck - 256 elevation, 19+03 CH, east end Unit 4
(2) Tailrace - 192 elevation, ℄ Unit 4, damaged - needs to be replaced
(3) Tailrace - 192 elevation, west end Unit 7
(4) Tailrace - 192 elevation, ℄ Unit 12, damaged - needs to be replaced
(5) Tailrace - 192 elevation, at border

(G) HUGGENBERGER CRACK GAUGES (Qty = 32)

(1) HGRS2
(2) HG22N
(3) HG22N2
(4) HG22N
(5) HG22N4
(6) HG22N
(7) HH22N6

TABLE I (cont'd)

(G) HUGGENBERGER CRACK GAUGES (Qty = 32) (cont'd)

(8) HG44W9
(9) HG44W10
(10) HG44W

(11) HG55E7
(12) HG55E8
(13) HG66S12
(14) HGFL29
(15) HGFL30
(16) HGFLS
(17) HGFLS
(18) HG66S1
(19) HG66S1
(20) HG66S16
(21) HG66S17
(22) HG66S18

(23) HG66S1
(24) HG66S2
(25) HG66S2
(26) HG66S2
(27) HG66S2
(28) HGSW13
(29) HG1G24
(30) HG1G25
(31) HG1G25
(32) HG1G27

(H) TAPE EXTENSOMETERS (Qty = 8)

WTE1	S1 Level equipment gallery + cable gallery
WTE2	S1 Level equipment gallery + cable gallery
WTE3	S1 Level equipment gallery + cable gallery
ETE19	S1 Level equipment gallery + cable gallery
ETE20	S1 Level equipment gallery + cable gallery
ETE21	S1 Level equipment gallery + cable gallery
ETE22	S1 Level equipment gallery + cable gallery

TABLE I (cont'd)

(I) R.H. SAUNDERS GENERATION STATION
Thermocouple Monitoring (Qty = 44)

AREA	LOCATION	LABEL	DEPTH (ft)	CODE	
S3 level	Upstream Wall	TCS3-1S	0	yellow	
		TCS3-1D	4	red	
	Downstream (middle room)	*TCS3-2S*	0	yellow	
		TCS3-2D1	1.5	red	
		TCS3-2D2	3	white	
S4 level	Upstream Wall	TCS4-1S	0	yellow	Monitored by Soil Sciences manually during load testing (March 1 to March 10/91)
		TCS4-1D1	6	red	
		TCS4-1D2	12	white	
	Gallery Floor	TCS4-2D1	6	red	
		TCS4-2D2	12	white	
	Downstream Floor (3rd room)	TCS4-3D	6	red	
	Downstream (middle room)	TCS4-4S	0	yellow	
		TCS4-4D1	1.5	red	
		TCS4-4D2	3	white	
Inspection Gallery	Floor (upstream)	*TCIG1D1*	6	red	
		TCID1D2	12	white	
	Floor (downstream)	*TCIG2S*	0	yellow	
		TCID2D1	6	red	
		TCID2D2	12	white	
	Upstream Wall	*TCID3D*	6	red	
	Downstream Wall	*TCID4D1*	6	red	
		TCID4D2	12	white	

TABLE I (cont'd)

(I) R.H. SAUNDERS GENERATION STATION
Thermocouple Monitoring (cont'd)

AREA	LOCATION	LABEL	DEPTH (ft)	CODE
EL. 258	Upstream Deck	TCCR1S	0	yellow
		TCCR1D	6	red
		TCCR2S	0	yellow
		TCCR2D	3	red
EL. 220	Wall	TC220S	0	yellow
		TC220D	4	red
EL. 192	Wall	TC192-1S	0	yellow
	Downstream Deck	TC192-2S	0	-
		TC192-2D	3	-
EL. 180	Gallery Upstream Wall	TC180-1D	6	red
		TC180-1D2	12	white
	Gallery Floor	TC180-2S	0	yellow
		TC180-2D	6	red
	Generator Room Upstream Wall	TC180-3S	0	yellow
	Generator Room West Wall	*TC180-4S*	0	yellow
S1 level	Upstream Wall	TCS1-1S	0	yellow
		TCS1-1D	6	red
S2 level	Downstream Wall	TCS2-1S	0	yellow
		TCS2-1D	1.5	red
		TCS2-1D2	3	white
	Upstream Wall	TCS2-2S	0	yellow
		TCS2-2D	6	red

R.H.SAUNDERS GS
UNIT 4
NORMAL PENDULUM READINGS - UPSTREAM

SUMMARY OF RESULTS

DATE	TIME	N/S RDG (mm)	E/W RDG (mm)	INVAR BLOCK (mm)	ADJUSTED N/S RDG (mm)	ADJUSTED E/W RDG (mm)	ADJUSTED INVAR BLOCK (mm)	COMMENTS
22-Feb-91	12:00 PM	24.765	88.443	38.887	23.425	88.313	29.981	
01-Mar-91	10:45 AM	24.950	88.570	38.567	23.420	88.230	29.651	new zero1
01-Mar-91	08:00 PM	24.780	88.390	NA	23.250	88.040	NA	note1
02-Mar-91	09:22 AM	23.480	88.400	NA	21.950	88.080	NA	note1
02-Mar-91	01:00 PM	25.140	88.790	28.931	23.610	88.440	29.651	
02-Mar-91	04:20 PM	25.160	88.780	28.931	23.630	88.420	29.651	
03-Mar-91	09:10 AM	24.810	88.770	29.159	23.280	88.430	29.880	
03-Mar-91	12:15 PM	24.850	88.710	29.083	23.320	88.370	29.804	
03-Mar-91	04:05 PM	24.980	88.790	29.235	23.450	88.450	29.956	
03-Mar-91	05:10 PM	24.910	88.780	29.298	23.380	88.440	29.007	
07-Mar-91	11:05 AM	25.100	88.800	29.185	23.570	88.460	28.905	
07-Mar-91	04:15 PM	25.150	88.860	29.185	23.620	88.520	28.905	
08-Mar-91	11:00 AM	23.620	88.520	28.906	23.620	88.520	28.905	new zero2
08-Mar-91	02:45 PM	23.570	88.580	28.905	23.570	88.580	28.905	
08-Mar-91	09:40 PM	23.550	88.580	28.905	23.550	88.580	28.905	
09-Mar-91	07:30 AM	23.580	88.480	28.931	23.580	88.480	28.931	
09-Mar-91	12:30 PM	23.490	88.580	28.854	23.490	88.580	28.854	
09-Mar-91	03:00 PM	23.420	88.470	NA	23.420	88.470	NA	
09-Mar-91	06:20 PM	23.660	88.520	NA	23.660	88.520	NA	
09-Mar-91	08:40 PM	23.610	88.450	NA	23.610	88.450	NA	
10-Mar-91	07:55 AM	23.480	88.430	29.007	23.480	88.430	29.007	
10-Mar-91	11:00 AM	23.420	88.470	29.108	23.420	88.470	29.108	

NOTE: ADJUSTMENTS N/S IS -1.53 mm (MAR8-7) AND +0.19 mm (FEB22-MAR1)

ADJUSTMENTS E/W IS -0.34 mm (MAR8-7) AND +0.21 mm (FEB22-MAR1)

ADJUSTMENTS INVAR IS -0.011 INCHES (MAR8-7) AND +0.379 INCHES (FEB22-MAR1)

note1 - invar wire affecting pend wire rdgs. (deleted rdgs)

(broken invar at deck level may have pushed pendulum wire - replaced with new wire)

note2 - inclinometer cable tangled with pend wire (untangled and took zeros)

(repositioned pend wire)

N/S +VE CHANGE IS MORE SOUTH

E/W +VE CHANGE IS MORE EAST

TABLE III - Normal and Inverse Pendulums (20 + 63.5 and 20 + 61.5)

R.H.SAUNDERS GS
UNIT 6

NORMAL PENDULUM READINGS - UPSTREAM

SUMMARY OF RESULTS

DATE	TIME	NORMAL N/S RDG (mm)	NORMAL E/W RDG (mm)	INVAR BLOCK (mm)	INVERSE N/S RDG (mm)	INVERSE E/W RDG (mm)	CALIBRATION BLOCK INVAR PIN (mm)	DATUM N/S (mm)	DATUM E/W (mm)	COMMENTS
01-Mar-91	10:00 AM	21.27	129.87	2.181	29.14	142.93	2.471	8.61	93.85	
01-Mar-91	06:30 PM	21.30	129.88	2.183	29.01	142.93	2.471			
02-Mar-91	09:26 AM	21.02	130.03	2.183	29.14	143.18	2.470	8.67	93.83	UNIT #4 DOWN- STILL WATERED TO S1
02-Mar-91	01:35 PM	21.07	129.98	2.181	29.08	143.12	2.470			
02-Mar-91	04:15 AM	20.79	130.11	2.181	29.09	143.11	2.471			
03-Mar-91	09:25 AM	20.54	130.11	2.178	29.02	143.04	2.469	8.67	93.83	UNIT #4 DOWN- STILL WATERED TO S1
03-Mar-91	12:25 PM	20.49	129.88	2.178	29.04	142.93	2.470			
03-Mar-91	06:45 PM	20.63	130.10	2.179	29.00	142.98	2.469			
07-Mar-91	11:20 AM	20.94	129.58	2.179	29.10	142.71	2.469			DEWATERED
07-Mar-91	06:05 PM	20.61	130.26	2.178	28.42	142.33	2.469			
08-Mar-91	11:10 AM	21.54	129.80	2.182	28.61	142.51	2.469	8.65	93.83	DEWATERED
08-Mar-91	03:25 PM	21.54	129.82	2.182	29.03	142.54	2.469			
09-Mar-91	07:40 AM	24.80	128.58	2.179	28.60	143.06	2.467			WATERED TO TAILRACE
09-Mar-91	08:16 AM	24.40	128.58	NA	NA	NA	NA			CHECK
09-Mar-91	08:17 AM	24.41	128.59	NA	NA	NA	NA			WIRE AND WEIGHT NOT MOVING FREELY IN BUCKET
09-Mar-91	12:25 PM	24.25	128.60	2.180	28.65	143.10	2.467			WATERED UP
09-Mar-91	06:06 PM	24.23	128.59	2.180	28.61	143.00	2.468			
10-Mar-91	09:00 AM	24.27	128.62	2.180	28.68	143.07	2.467			OPERATING
10-Mar-91	11:25 AM	24.21	128.55	2.180	28.65	143.06	2.467			OPERATING AFTER LOAD REJECTION TEST

NOTE: CALIBRATION TAKEN FOR OPTICAL READOUT
N/S +VE CHANGE IS MORE SOUTH
E/W +VE CHANGE IS MORE EAST

TABLE IV - Normal and Inverse Pendulum (26 + 15 and 26 + 18.5)

R.H.SAUNDERS GS
UNIT 12

NORMAL PENDULUM READINGS - UPSTREAM

SUMMARY OF RESULTS

DATE	TIME	NORMAL N/S RDG (mm)	NORMAL E/W RDG (mm)	INVAR BLOCK (mm)	INVERSE N/S RDG (mm)	INVERSE E/W RDG (mm)	CALIBRATION BLOCK INVAR BLOCK (mm)	CALIBRATION BLOCK DATUM N/S (mm)	CALIBRATION BLOCK DATUM E/W (mm)	COMMENTS
01-Mar-91	10:30 AM	30.72	93.29	2.175	28.99	136.80	2.206	8.61	93.85	
02-Mar-91	09:55 AM	30.62	93.28	2.176	29.06	136.80	2.207			
05-Mar-91	08:40 AM	30.68	93.22	2.173	29.01	136.71	2.207	8.67	93.83	UNIT #4 DOWN -STILL WATERED TO S1
07-Mar-91	11:40 AM	30.64	93.07	2.172	28.90	136.56	2.206			UNIT #4 DEWATERED
07-Mar-91	05:30 PM	30.71	93.06	2.169	28.94	136.67	2.203			
08-Mar-91	11:20 AM	30.63	93.15	2.175	28.87	136.74	2.206			DEWATERED
08-Mar-91	03:30 PM	30.73	93.13	2.172	28.87	136.76	2.207			
09-Mar-91	07:50 AM	30.79	93.13	2.175	28.87	136.76	2.207			WATERED TO TAILRACE
09-Mar-91	08:05 AM	31.44	93.70	NA	NA	NA	NA			MOVED WIRE IN BUCKET
09-Mar-91	09:20 AM	31.21	93.33	NA	NA	NA	NA			
09-Mar-91	12:40 PM	31.03	93.16	2.175	28.87	136.74	2.206			
09-Mar-91	06:40 PM	30.93	93.14	2.174	28.88	136.76	2.206			
10-Mar-91	08:10 AM	30.88	93.11	2.175	28.86	136.79	2.208			OPERATING

NOTE: CALIBRATION TAKEN FOR OPTICAL READOUT
N/S +VE CHANGE IS MORE SOUTH
E/W +VE CHANGE IS MORE EAST

TABLE V - Normal Pendulum - Stiarwell (19 + 77.5)

R.H.SAUNDERS GS
UNIT 4 PENDULUM READINGS
NORMAL STAIRWELL PENDULUM - LEVEL S4

SUMMARY OF RESULTS

DATE	TIME	ABSOLUTE POSITION N/S (mm)	ABSOLUTE POSITION E/W (mm)	REFERENCE DATUM MAR8/91 12pm DIFFERENCE (*) N/S (mm)	REFERENCE DATUM MAR8/91 12pm DIFFERENCE (*) E/W (mm)	DAILY DIFF (**) N/S (mm)	DAILY DIFF (**) E/W (mm)	CUMULATIVE DIFF (***) N/S (mm)	CUMULATIVE DIFF (***) E/W (mm)
01-Mar-91	08:00 AM	38.770	97.310	0.12	-0.08				
01-Mar-91	07:00 PM	38.690	97.280	-0.05	-0.10	0.17	0.02	0.17	0.02
02-Mar-91	08:00 AM	38.800	97.430	-0.05	0.04	0.00	-0.14	0.17	-0.12
02-Mar-91	02:30 PM	38.650	97.200	0.03	-0.19	-0.05	0.23	0.12	0.11
02-Mar-91	05:30 PM	38.650	97.320	0.04	-0.07	-0.04	-0.12	0.08	-0.01
03-Mar-91	08:30 AM	38.660	97.200	0.00	-0.19	0.04	0.12	0.12	0.11
03-Mar-91	11:30 AM	38.640	97.360	-0.01	-0.03	0.01	-0.16	0.13	-0.05
03-Mar-91	04:30 PM	38.660	97.360	0.01	0.00	-0.02	-0.03	0.11	-0.08
07-Mar-91	10:30 AM	38.630	97.360	-0.02	-0.03	0.03	0.03	0.14	-0.05
07-Mar-91	05:00 PM	38.700	97.480	0.06	0.09	-0.07	-0.12	0.07	-0.17
08-Mar-91	10:00 AM	38.610	97.480	-0.04	0.08	0.09	0.00	0.16	-0.17
08-Mar-91	03:00 PM	38.660	97.480	0.00	0.10	-0.04	-0.01	0.12	-0.18
08-Mar-91	07:00 AM	38.740	97.390	0.09	0.00	-0.09	0.10	0.03	-0.08
08-Mar-91	11:45 AM	38.650	97.390	0.00	0.00	0.09	0.00	0.12	-0.08
08-Mar-91	05:30 PM	38.800	97.380	0.15	0.00	-0.15	0.00	-0.03	-0.08
10-Mar-91	07:00 AM	38.620	97.450	-0.03	0.06	0.18	-0.06	0.15	-0.14
10-Mar-91	10:30 AM	38.650	97.250	0.00	-0.14	-0.03	0.20	0.12	0.06

NOTE:(*) REFERENCE DATUM USED MARCH 8, 1991

TOTAL CHANGE IN POSITION OF THE WIRE WITH RESPECT TO MAR8/91

(**) DAILY DIFFERENTIAL CHANGE IN POSITION OF THE WIRE WITH RESPECT TO MAR8/91

(***) CUMULATIVE DIFFERENTIAL CHANGE IN POSITION OF THE WIRE WITH RESPECT TO MAR8/91

N/S +VE CHANGE IS MORE NORTH

E/W +VE CHANGE IS MORE WEST

TABLE VI - Adjustments Made to Autocenering Readings

R.H.Saunders Generating Station
Normal Pendulum Datum Auto Center
Unit 4
SUMMARY OF CORRECTIONS AND ZERO READINGS NECESSARY TO ADJUST AUTOCENTERING READINGS

DATE	TIME	ZERO RDG N/S (mm)	ZERO RDG E/W (mm)	COMMENTS
FEB 14/91		24.98	88.66	Table rdg taken - next a/c rdg
MAR 01/91	10:45 am	24.95	88.57	Last table rdg taken before wire broke
MAR 02/91	1:15 pm	25.14	88.78	First rdg after repositioning 'zero' taken
MAR 03/91	A/C	25.00	88.84	Table rdg taken - next a/c rdg
MAR 07/91	4:15 pm	25.15	88.86	Table rdg and a/c
MAR 08/91	11:00 am	23.62	88.52	First rdg after repositioning 'zero' taken
MAR 09/91	2:56 pm	23.42	88.47	Table rdg and a/c - 'PRESENT ZERO' used as datum

TABLE VII

Corrected Autocentering Readings for Pendulum (19 + 03)

R.H.Saunders Generating Station
Normal Pendulum Datum Auto Center
Absolute Position of the pendulum wire

SUMMARY OF RESULTS

Depth (ft)	Depth (m)	FEB14/91 ABSOLUTE POSITION N/S (mm)	FEB14/91 ABSOLUTE POSITION E/W (mm)	MAR01/91 ABSOLUTE POSITION N/S (mm)	MAR01/91 ABSOLUTE POSITION E/W (mm)	MAR03/91 ABSOLUTE POSITION N/S (mm)	MAR03/91 ABSOLUTE POSITION E/W (mm)	MAR7/91 ABSOLUTE POSITION N/S (mm)	MAR7/91 ABSOLUTE POSITION E/W (mm)	MAR9/91 ABSOLUTE POSITION N/S (mm)	MAR9/91 ABSOLUTE POSITION E/W (mm)
6	1.83	1.93	2.85								
8	2.44	1.64	4.32	1.65	5.11	2.01	4.85	0.94	3.68	3.24	4.91
10	3.05	2.14	5.33								
12	3.66	3.02	5.76	3.12	5.71	3.14	6.01	2.7	5.69	5.05	6.59
14	4.27	3.93	5.7								
16	4.88	3.98	5.08	4.13	3.71	3.92	3.67	3.9	3.78	5.62	4.08
18	5.49	4.57	4.12								
20	6.10	4.84	5.21	4.78	4.6	4.53	4.48	4.59	4.38	6.14	4.91
22	6.71	3.01	6.45								
24	7.32	2.15	6.23	1.68	5.91	1.51	5.79	1.52	5.82	2.94	6.12
26	7.92	-0.59	5.08								
28	8.53	-3.18	4.23	-2.19	4.29	-2.3	4.04	-2.23	3.95	-0.84	4.56
30	9.14	-4.88	3.94								
32	9.75	-5.09	3.73	-4.38	3.97	-4.57	3.75	-4.39	3.84	-2.98	4.17
34	10.36	-8.82	2.92								
36	10.97	-11.03	1.99	-9.09	2.12	-9.26	2.02	-9.12	1.8	-7.75	2.36
38	11.58	-11.86	1.06								
40	12.19	-12.33	-0.56	-10.56	-0.4	-10.75	-0.82	-10.74	-0.54	-9.31	-0.12
42	12.80	-12.4	-2.64								
44	13.41	-11.11	-4.36	-9.52	-4.1	-9.68	-4.3	-9.83	-4.18	-8.29	-3.9
46	14.02	-9.15	-4.72								
48	14.63	-7.41	-4.43	-5.92	-3.9	-5.98	-4.08	-6.13	-4.19	-4.61	-3.87
50	15.24	-5.99	-3.57								
52	15.85	-5.21	-2.32	-4.52	-1.25	-4.36	-1.33	-4.43	-1.38	-2.99	-1
54	16.46	-4.24	-0.73								
56	17.07	-3.22	0.39	-1.83	0.98	-1.83	0.48	-1.89	0.49	-0.29	0.92
58	17.68	-2.45	0.92								
60	18.29	-1.33	1.1	0.22	1.39	0.12	0.9	0.03	1.24	1.67	1.54
62	18.90	0.18	1.04								
64	19.51	1.82	0.66	2.88	1.56	3.21	0.33	3.13	0.51	4.77	0.79
66	20.12	3.33	-0.45								
68	20.73	3.98	-1.61	5.16	-0.84	5.22	-1.59	5.3	-1.78	6.81	-1.23
70	21.34	3.88	-2.58								
72	21.95	3.34	-3.97	4.65	-3.04	4.94	-3.88	4.78	-4.13	6.61	-3.79
74	22.56	4.07	-4.51								
76	23.18	4.88	-4.3	6.35	-3.33	5.91	-3.93	6.27	-4.3	8.06	-3.99

TABLE VII (cont'd)

78	23.77	3.8	-4.37								
80	24.38	2.82	-4.79	4.31	-4.37	3.95	-4.9	4.36	-5.22	6.08	-4.8
82	24.99	-0.22	-6								
84	25.60	-3.85	-5.26	-1.19	-5.38	-1.72	-5.25	-1.82	-5.41	-0.03	-4.96
86	26.21	-6.54	-5.67								
88	26.82	-8.07	-6.23	-6.56	-5.48	-6.46	-6.18	-6.44	-6.26	-4.78	-5.86
90	27.43	-9.88	-6.38								
92	28.04	-11	-7.39	-9.74	-6.42	-9.86	-6.75	-9.78	-6.52	-8.04	-6.36
94	28.65	-11.11	-8.43								
96	29.26	-10.8	-8.87	-9.48	-7.81	-9.61	-8.19	-9.85	-8.02	-8.04	-7.71
98	29.87	-11.52	-7.84								
100	30.48	-12.27	-5.92	-10.32	-4.84	-10.74	-4.94	-11.1	-4.57	-9.48	-4.26
102	31.09	-10.64	-3.15								
104	31.70	-10.45	-2.33	-9.38	-0.92	-9.09	-1.83	-9.55	-1.58	-7.71	-1.16
106	32.31	-10.66	-1.44								
108	32.92	-11.95	-0.69	-9.5	0.25	-10.21	0.06	-10.52	0.43	-8.94	0.81
110	33.53	-12.48	1.25								
112	34.14	-13.53	3.65	-10.56	4.34	-12.12	5.74	-12.45	5.4	-10.68	5.79
114	34.75	-13.6	5.99								
116	35.36	-15.01	7.09	-12.19	7.22	-12.74	7.56	-13.67	8.05	-11.96	8.55
118	35.97	-16.72	8.54								
120	36.58	-10.55	8.39	-10.47	8.66	-10.86	8.91	-10.43	9.59	-7.74	10.01

NOTE: Absolute wire position referenced to March 09, 1991 at the top of the headworks

N/S +VE CHANGE TOWARDS SOUTH

E/W +VE CHANGE TOWARDS EAST

TABLE VIII - Inverse Pendulum (19 + 77.5) Table Readings for Unit 4

R.H.SAUNDERS GS
UNIT 4 INVERSE PENDULUM TABLE READINGS ON LEVEL S1, S2, S3 AND S4
SUMMARY OF RESULTS

		LEVEL S1			LEVEL S2			LEVEL S3			LEVEL S4		
DATE	TIME	N/S RDG (mm)	E/W RDG (mm)	INVAR RDG (mm)	N/S RDG (mm)	E/W RDG (mm)	INVAR RDG (mm)	N/S RDG (mm)	E/W RDG (mm)	INVAR RDG (mm)	N/S RDG (mm)	E/W RDG (mm)	INVAR RD (mm)
29-Jan-91	08:00 AM	16.360	98.580	27.380	15.480	92.280	25.300	13.830	92.540	30.300	25.020	93.790	28.090
29-Jan-91	02:30 PM	16.290	98.600	27.380	15.530	92.100	25.300	13.820	92.550	30.350	25.010	93.780	28.070
29-Jan-91	10:30 AM	16.240	98.580	27.410	15.550	92.150	25.220	13.810	92.420	30.310	25.000	93.750	28.040
22-Feb-91	12:00 PM	16.027	98.114	27.254	15.291	92.100	25.070	13.716	92.481	30.150	24.943	93.701	27.940
01-Mar-91	08:00 AM	16.100	98.100	27.303	15.230	92.020	24.988	13.690	92.330	30.134	24.920	93.740	27.762
01-Mar-91	07:00 PM	16.130	98.110	27.229	15.290	92.000	24.988	13.670	92.340	30.150	24.940	93.730	27.788
02-Mar-91	08:00 AM	16.060	98.060	27.229	15.220	92.030	24.994	13.690	92.490	30.074	24.920	93.790	27.888
02-Mar-91	02:30 PM	16.090	98.010	27.303	15.290	91.960	24.943	13.660	92.380	30.074	24.920	93.760	27.762
02-Mar-91	05:30 PM	16.140	98.020	27.203	15.280	91.980	24.943	13.680	92.390	30.074	24.900	93.710	27.788
03-Mar-91	08:30 AM	16.060	98.140	27.229	15.210	91.980	24.988	13.690	92.450	30.074	25.200	93.720	27.762
03-Mar-91	11:30 AM	16.060	98.150	27.229	15.220	92.030	24.988	13.660	92.480	30.048	24.880	93.780	27.711
03-Mar-91	04:30 PM	16.160	98.020	27.178	15.240	91.960	24.968	13.680	92.430	30.074	24.940	93.800	27.661
07-Mar-91	10:30 AM	16.020	98.130	27.127	15.170	91.880	24.892	13.630	92.380	30.023	24.980	93.970	27.686
07-Mar-91	08:00 PM	16.000	98.200	27.127	15.200	91.990	24.943	13.630	92.500	30.023	24.970	93.900	27.686
08-Mar-91	10:00 AM	15.940	98.140	27.153	15.200	91.950	24.884	13.710	92.500	30.048	24.880	93.780	27.737
08-Mar-91	03:00 PM	15.930	98.150	27.102	15.210	91.970	24.943	13.640	92.520	29.972	24.920	93.800	27.737
08-Mar-91	07:00 AM	15.860	98.180	27.102	15.150	91.960	24.968	13.560	92.420	30.048	24.910	93.800	27.686
08-Mar-91	11:45 AM	15.920	98.150	27.051	15.130	91.930	24.968	13.570	92.400	30.023	24.880	93.730	27.661
09-Mar-91	08:30 PM	15.920	98.100	27.127	15.160	91.920	24.943	13.550	92.340	29.972	24.880	93.630	27.737
10-Mar-91	07:00 AM	15.920	98.060	27.102	15.180	91.900	24.905	13.600	92.360	29.959	24.850	93.710	NA
10-Mar-91	10:30 AM	15.920	98.240	27.102	15.100	91.920	24.994	13.610	92.420	29.972	24.850	93.740	27.711
10-Mar-91	11:30 AM	15.940	98.140	27.102									

NOTE: N/S readings - a positive change is more North
E/W readings - a positive change is more West

TABLE IX - Autocentering Readings for Inverse Pendulum (19 + 77.5), Unit 4

R.H Saunders Generating Station
Auto Centering Readings - Inverse Pendulums
SUMMARY OF RESULTS

Depth (Ft)	Depth (m)	JAN 23/91 9:00AM ABSOLUTE POSITION N/S (mm)	E/W (mm)	JAN 23/91 3:00PM ABSOLUTE POSITION N/S (mm)	E/W (mm)	MAR1/91 11:30AM ABSOLUTE POSITION N/S (mm)	E/W (mm)	MAR7/91 2:00PM ABSOLUTE POSITION N/S (mm)	E/W (mm)	MAR10/91 1:00PM ABSOLUTE POSITION N/S (mm)	E/W (mm)
Initial											
3	0.91	-10.17	0.98	-10.02	1.17	-9.98	0.54	-10.01	0.66	-10.03	0.7
8	2.44	-13.58	-0.28	-13.34	-0.36	-13.35	-0.67	-13.52	-0.37	-13.46	-0.45
13	3.98	-17.38	0.61	-17.23	0.53	-17.17	0.46	-17.24	0.69	-17.15	0.61
18	5.49	-18.13	2.08	-18.12	2.01	-18.14	1.76	-18.15	1.87	-18.17	1.79
23	7.01	-13.47	3.11	-13.39	3.01	-13.43	2.92	-13.53	3.09	-13.46	3.04
28	8.53	-6.92	2.08	-6.89	2.08	-7.04	1.86	-7.06	2.02	-6.99	2.01
33	10.06	-0.98	0.47	-0.88	0.4	-1.02	0.22	-0.97	0.3	-0.93	0.31
38	11.58	0.9	0.06	1.03	0.01	0.91	-0.03	0.85	0.06	1.01	0.01
40	12.19	0.52	0.54	0.49	0.27	0.4	0.23	0.37	0.28	0.57	0.38

NOTE: A/C device has 2 ft. leader on chain to centreline wheels

Concrete surface is bottom of gutter - 2.5 ft. below

84 elevation (130 ft). All depthsare relative to top of NQ rods

at 6 inches above the floor (130.5 ft).

The first A/C MSMT at bottom of gutter - read 1 ft. on chain.

Anchor point is at elevation 89 ft. 2 inches from top of NQ

N/S - +ve change is more north

E/W - +ve change is more west

TABLE X - Vibrating Wire Extensometers on Level S1, Unit 4

R.H. SAUNDERS GS
Vibrating Wire Extensometer for Unit #4
SUMMARY OF RESULTS

DATE:	TIME:	Actual Deformation WVWE1 (mm)	Actual Deformation EVWE2 (mm)	Air Temperature WVWE1 (degrees C)	Air Temperature EVWE2 (degrees C)
01-Mar-91	08:40 AM	0.0000	0.0000	18	19
01-Mar-91	12:45 PM	0.0000	-0.0098	18	19
01-Mar-91	05:20 AM	0.0759	0.0588	19	20
02-Mar-91	07:45 AM	-0.0258	-0.1278	18	18
02-Mar-91	10:00 AM	0.0500	-0.0431	19	19
02-Mar-91	12:40 PM	0.0500	-0.0518	NA	NA
02-Mar-91	04:55 AM	0.0500	-0.0018	19	20
03-Mar-91	08:00 AM	0.0414	-0.0860	19	19
03-Mar-91	04:15 AM	0.0414	-0.0860	19	19
08-Mar-91	09:30 AM	-0.1895	-0.3808	18	18
08-Mar-91	12:45 PM	-0.1138	-0.3108	19	19
08-Mar-91	08:00 PM	-0.1589	-0.3442	NA	NA
09-Mar-91	07:00 AM	-0.2239	-0.3984	18	18
09-Mar-91	11:28 AM	-0.2087	NA	18	NA
09-Mar-91	11:29 AM	-0.2087	NA	18	NA
09-Mar-91	11:30 AM	-0.2087	NA	18	NA
09-Mar-91	11:31 AM	-0.2087	NA	18	NA
09-Mar-91	11:32 AM	-0.2828	NA	17	NA
09-Mar-91	11:33 AM	-0.2912	NA	17	NA
09-Mar-91	11:34 AM	-0.2828	-0.4795	17	17
09-Mar-91	11:37 AM	-0.2912	-0.4795	17	17
09-Mar-91	11:38 AM	-0.2828	NA	17	NA
09-Mar-91	11:39 AM	-0.2912	-0.4709	17	17
09-Mar-91	11:40 AM	NA	-0.4795	NA	17
09-Mar-91	12:25 PM	-0.2828	-0.4795	NA	NA
09-Mar-91	12:42 PM	-0.2828	-0.4795	NA	NA
09-Mar-91	03:45 PM	-0.2654	-0.4623	17	17
09-Mar-91	04:42 PM	-0.2654	-0.4623	17	17
09-Mar-91	08:35 PM	-0.2654	-0.4623	17	17
09-Mar-91	08:15 PM	-0.2567	-0.4537	17	17
10-Mar-91	07:15 AM	-0.2654	-0.4537	17	17
10-Mar-91	12:03 PM	-0.2740	-0.4623	17	17

NOTE: MONITORING AREA ON LEVEL S1 GENERATOR ROOM

MEASURING ALONG THE UPSTREAM/DOWNSTREAM DIRECTION

WVWE1 -S/N 2408

GAUGE FACTOR, G= 0.000332617 INCHES/DIGIT

EVWE2 - S/N 2407

GAUGE FACTOR, G= 0.000333177 INCHES/DIGIT

POSITIVE VALUES INDICATE EXTENSION OF EXTENSOMETER (POSITION 'B')

RECORDED AIT TEMPERATURE USED IN CORRECTIONS OTHERWISE AN ASSUMED VALUE WAS USED AS SHOWN ABOVE

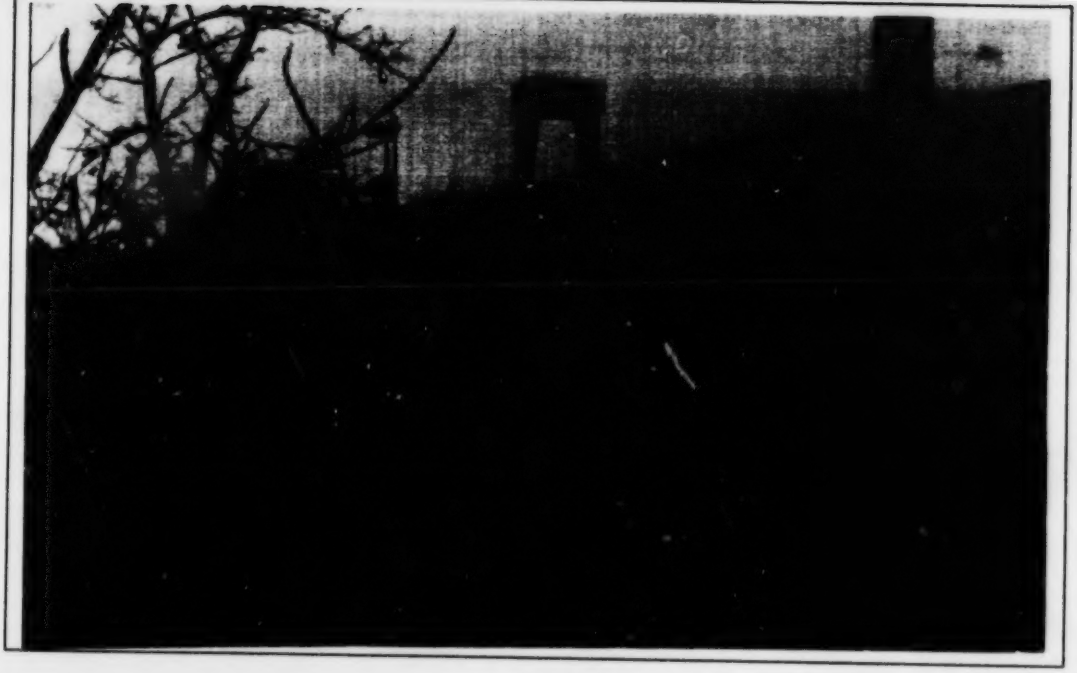
TABLE XI - Thermocouple Readings from Level S4, Unit 4

R.H.SAUNDERS GS
UNIT 4

SUMMARY OF RESULTS
MANUAL TEMPERATURE READINGS TAKEN ON LEVEL S4 (UPSTREAM)

		MEASURED TEMPERATURE (DEGREES C)								
	LABEL NUMBER	TC1G4D		TC1G2D			TC1G3	TC1G1	TC1G1D	
DATE	TIME	33 RED	34 WHITE	30 RED	31 YELLOW	32 WHITE	27 RED	28 RED	29 WHITE	
01-Mar-91	05:30 PM	12	12	12		11	12	6	10	10
02-Mar-91	08:00 AM	11	11	11		10	11	5	10	10
02-Mar-91	05:00 PM	11	11	11		10	11	5	10	10
03-Mar-91	10:30 AM	12	12	11		10	11	6	10	10
03-Mar-91	05:00 PM	11	11	11		10	11	6	10	10
06-Mar-91	05:30 PM	11	12	11		10	11	6	10	10
06-Mar-91	08:25 AM	11	12	11		10	12	6	10	10
06-Mar-91	12:20 PM	12	12	12		10	12	6	10	11
10-Mar-91	10:25 AM	11	12	12	BROKEN		12	6	10	10

NOTE: TC1G3D - U/S TUNNEL WALL U/S TUNNEL #27
TC1G1S AND TC1G1D - TUNNEL FLOOR #28
TC1G2D - D/S WALL U/S TUNNEL NEAR FLOOR #29, 30, 31
#33 D/S WALL U/S TUNNEL
#34- 3 INCHES OFF FLOOR



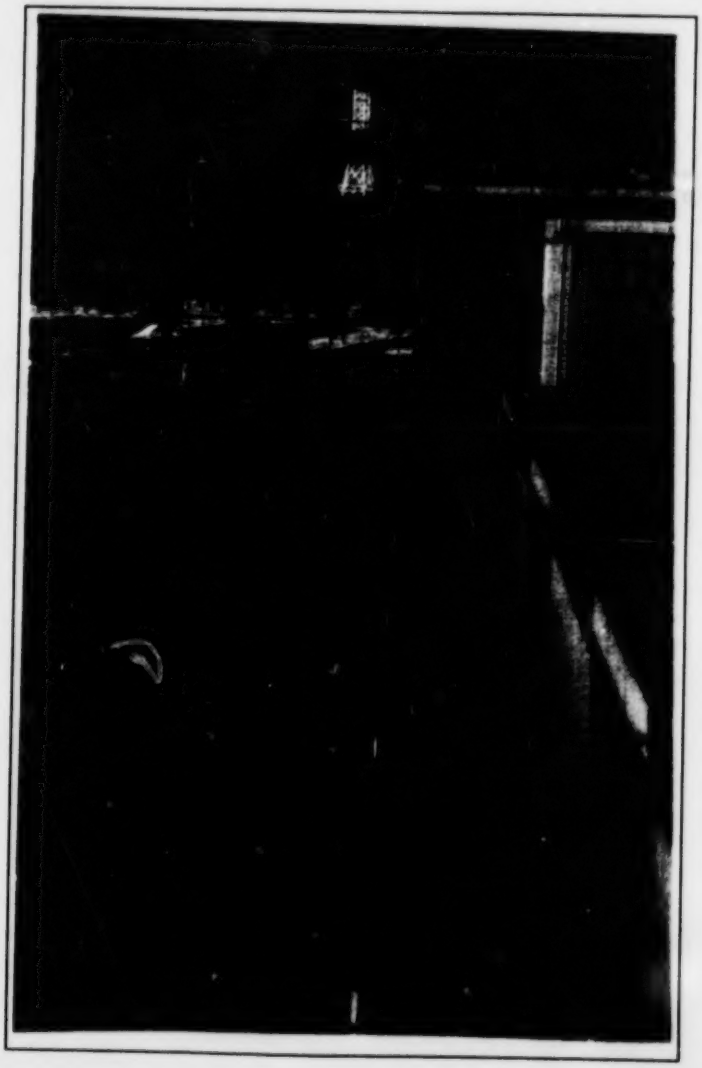
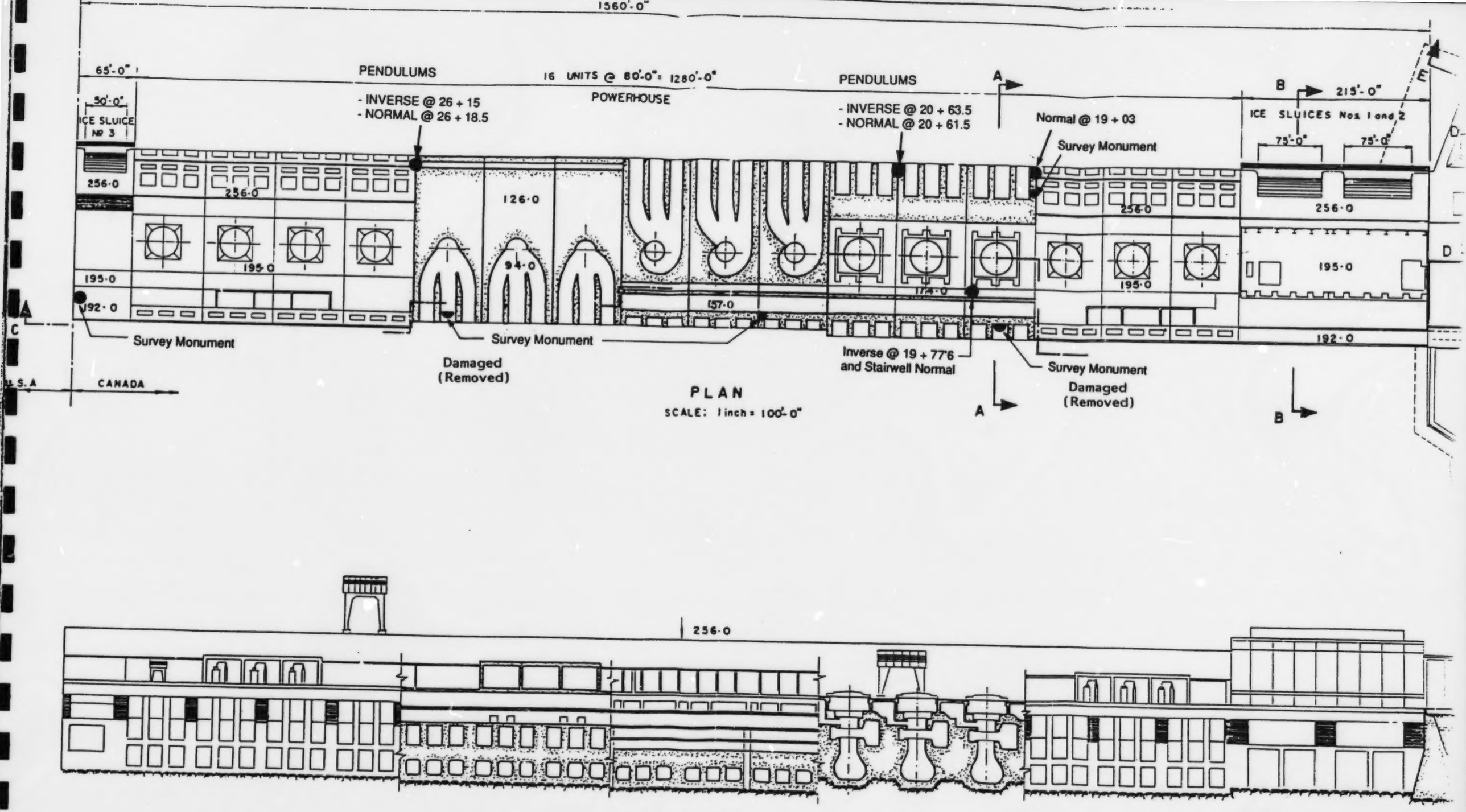


FIGURE 1

RH SAUNDERS GS
CANADIAN SIDE IN FOREGROUND

91-132
185987-B35-RD



PLAN

SCALE: 1 inch = 100'-0"

ELEVATION. C - C

SCALE: 1 inch = 100'-0"

This information taken from DWG. No. 254-e-77 sheet 4

FIGURE 2

PLAN & SECTION OF R.H. SAUNDERS G.S. SHOWING PENDULUM LOCATIONS

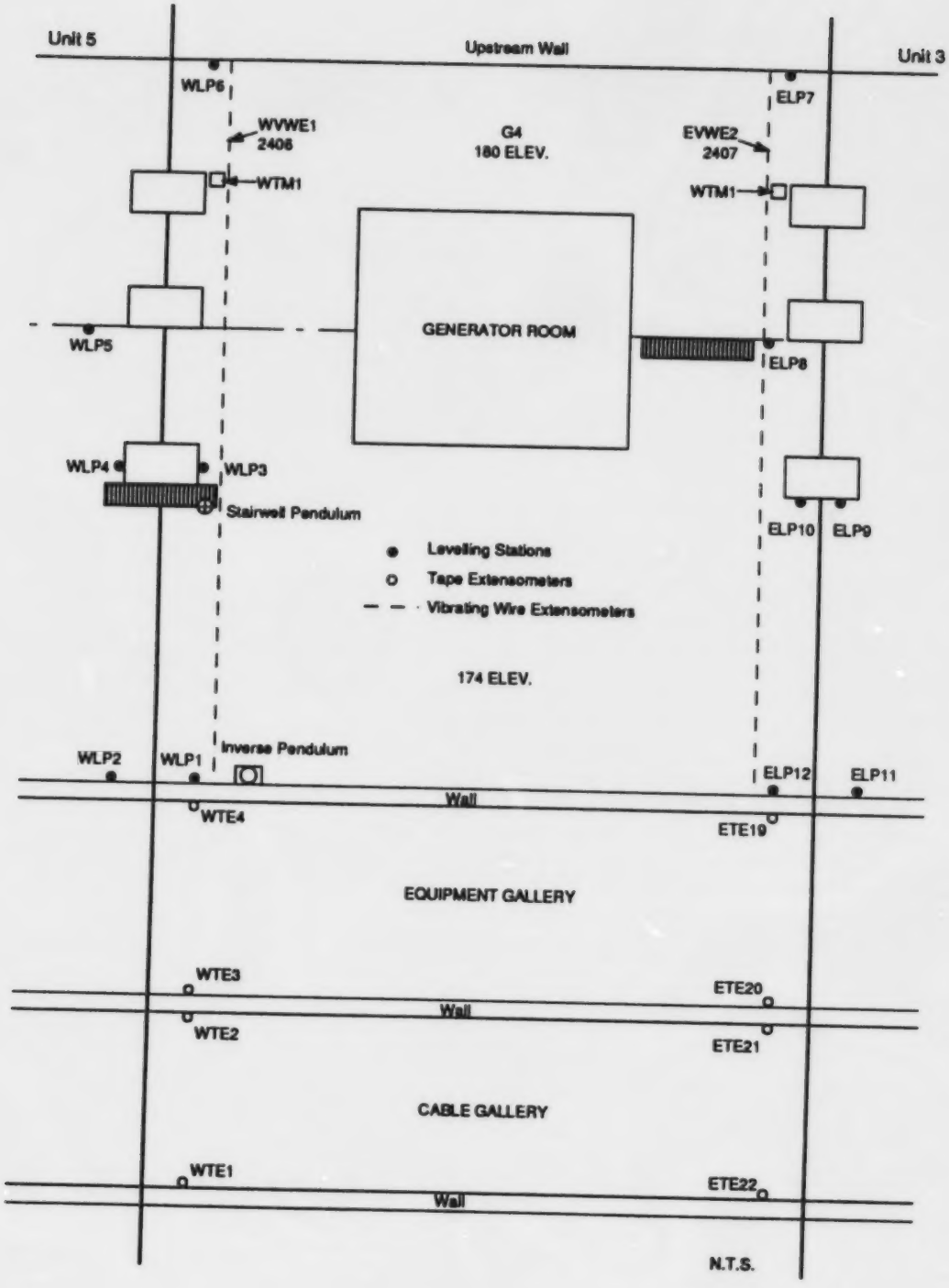


FIGURE 3

R.H. SAUNDERS G.S. - S1 ELEV INSTRUMENT LOCATIONS

91-132
185728-G42-RD

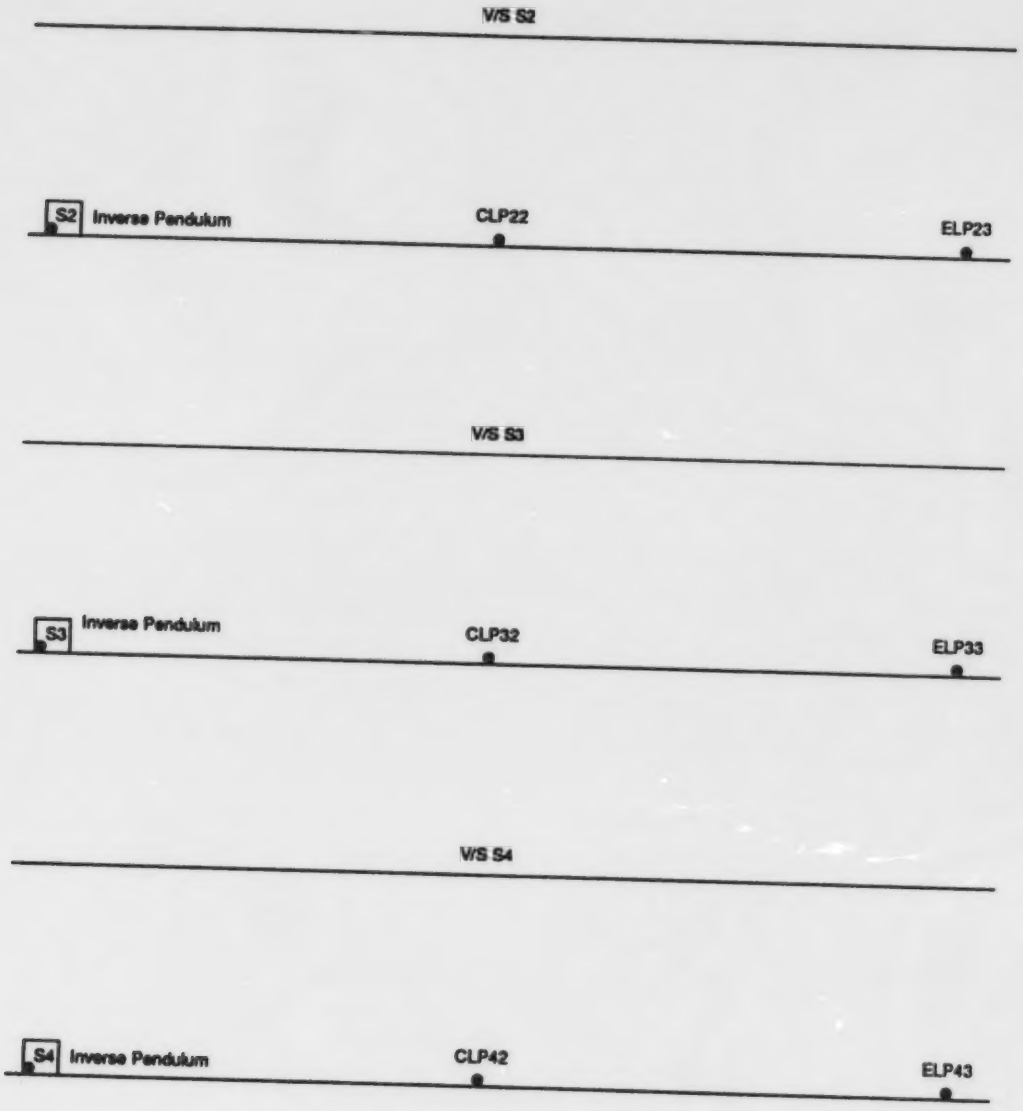


FIGURE 4

R.H. SAUNDERS G.S. - S2, S3, S4 ELEVATION STATIONS

91-132
185727-G42-RD

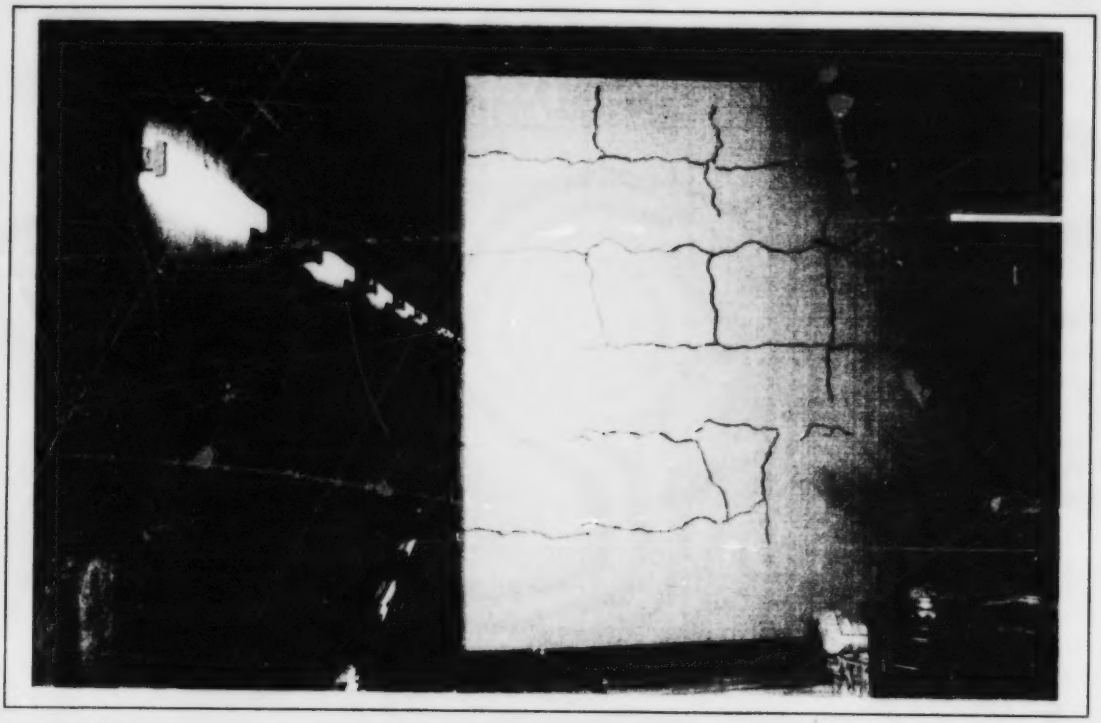
FIGURE 5

SURVEY ELEVATION STATIONS INSTALLED THROUGHOUT THE STATION TO MONITOR MOVEMENTS

FIGURE 6

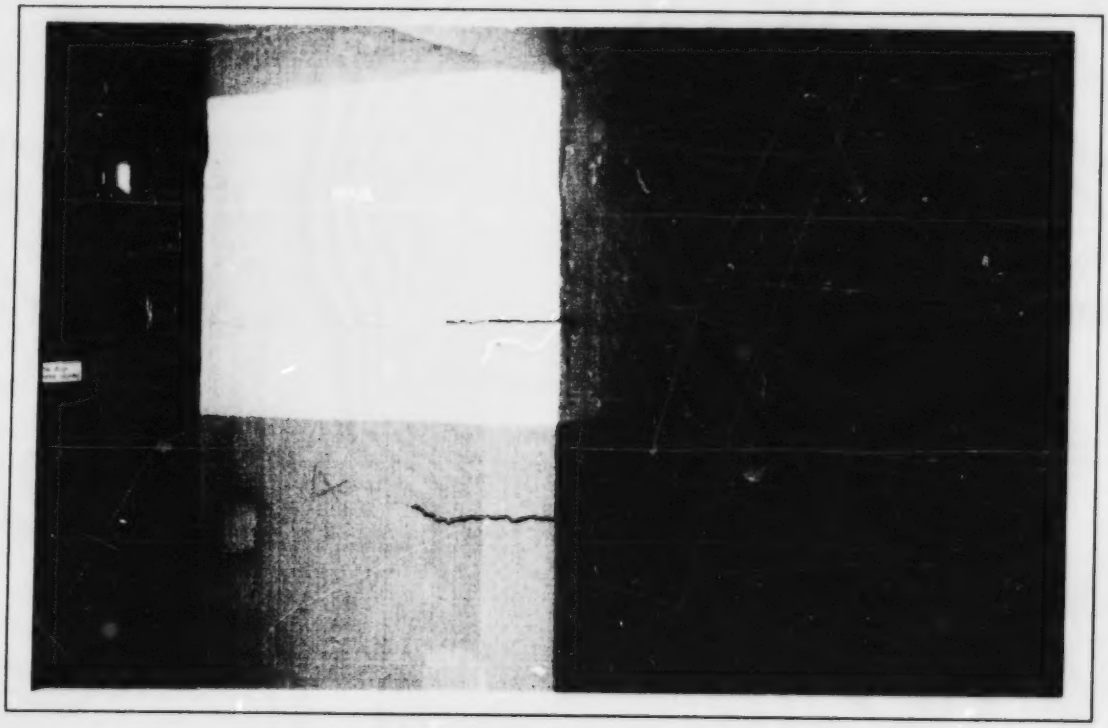
EXTENSIVE CRACKING NOTED ON LEVEL S2 NEAR THE CEILING (UPSTREAM SIDE)

91-132
185989-B34-RD



Upstream-side

(a) Level S1 - Unit 4
Crack pattern observed in support column



(b) Cracking near stairwell (upsteam-side) on Level S2

FIGURE 7

CONCRETE CRACKING OBSERVED ON LEVEL S1 AND S2

Glass crack indicator mounted across a major crack.

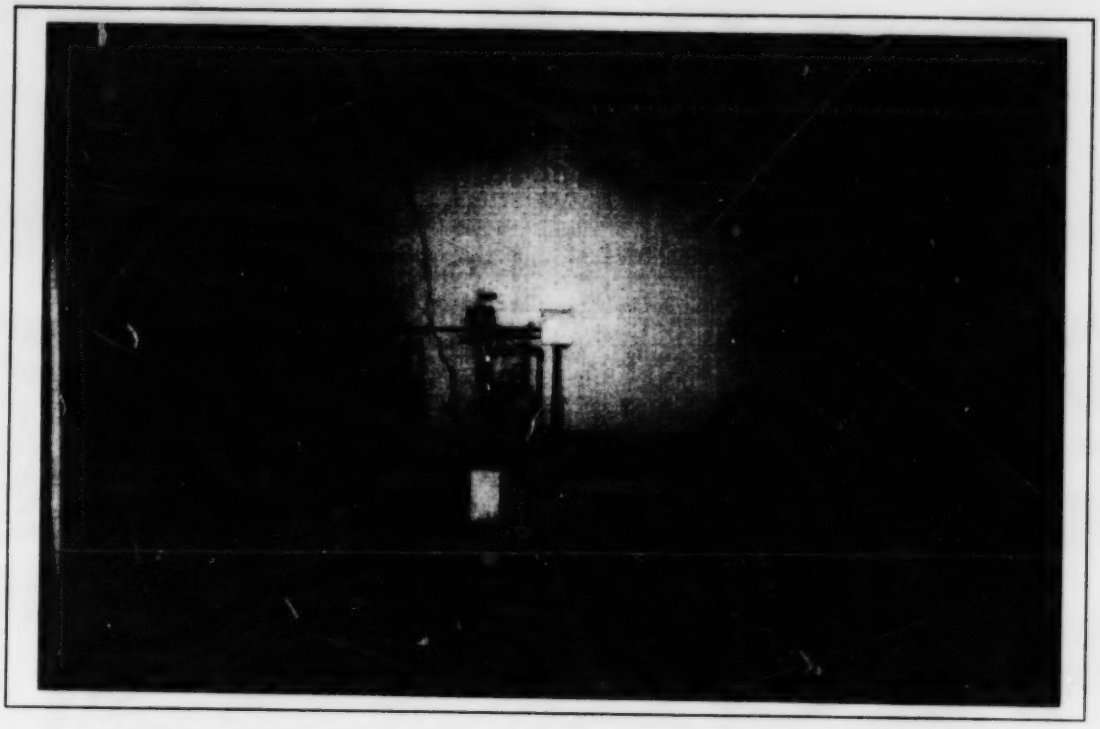
FIGURE 8

CRACKING PATTERN OBSERVED NEAR UNIT 7

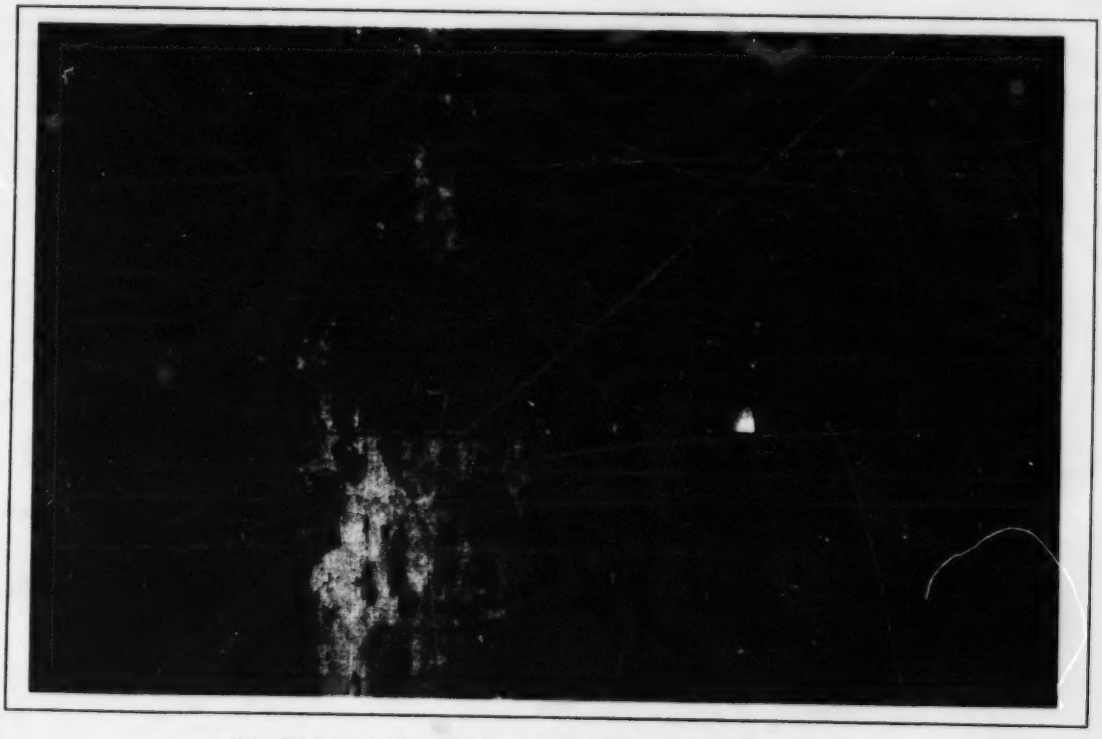
91-132
185991-B35-RD

FIGURE 9

CALCAREOUS PRECIPITATE FROM CONCRETE OBSERVED ON LEVEL S4 INSPECTION TUNNEL



(a) Robert Moses GS, NYPA. Crack pattern observed on American-side of structure.



(b) Joint meter installed across a concrete joint to measure movements in three directions. Only three meters are currently monitored by Americans.

FIGURE 10

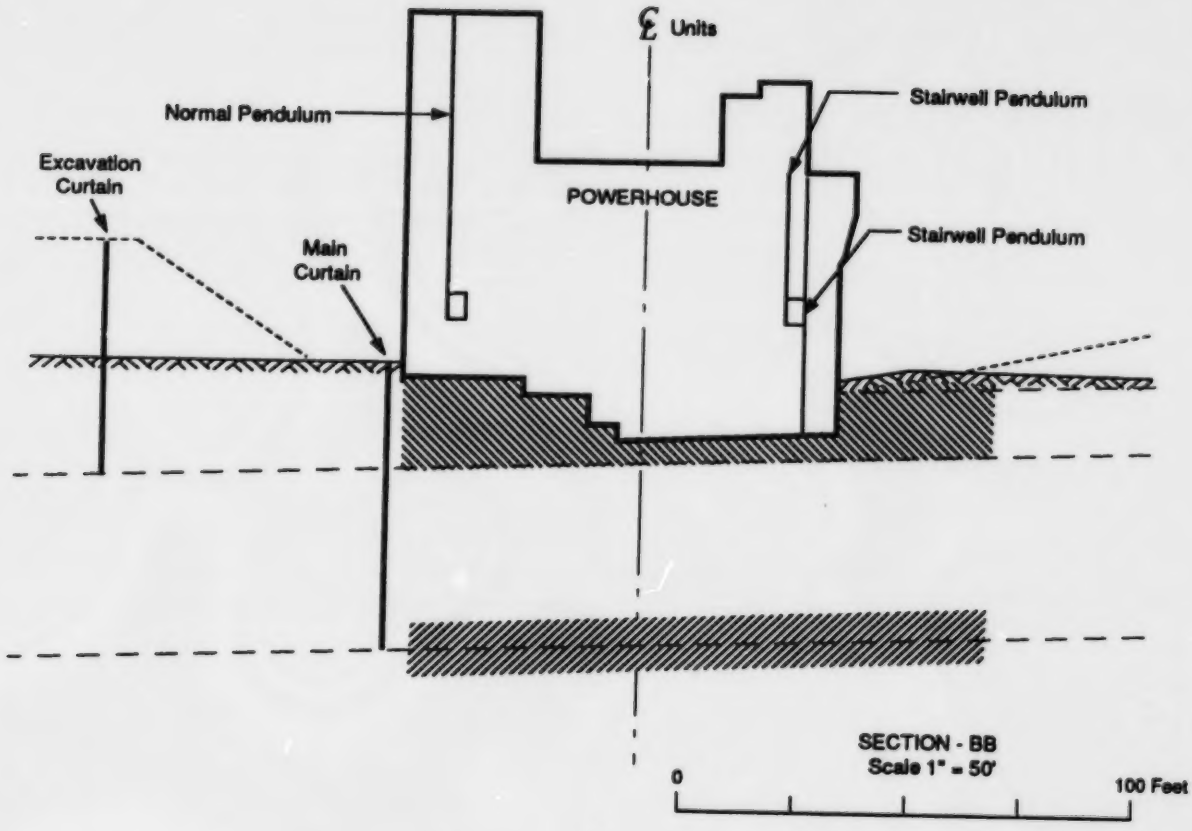


FIGURE 11

SAUNDERS G.S. - CROSS SECTION SHOWING PENDULUM LOCATIONS

91-132
185240-G42-RD

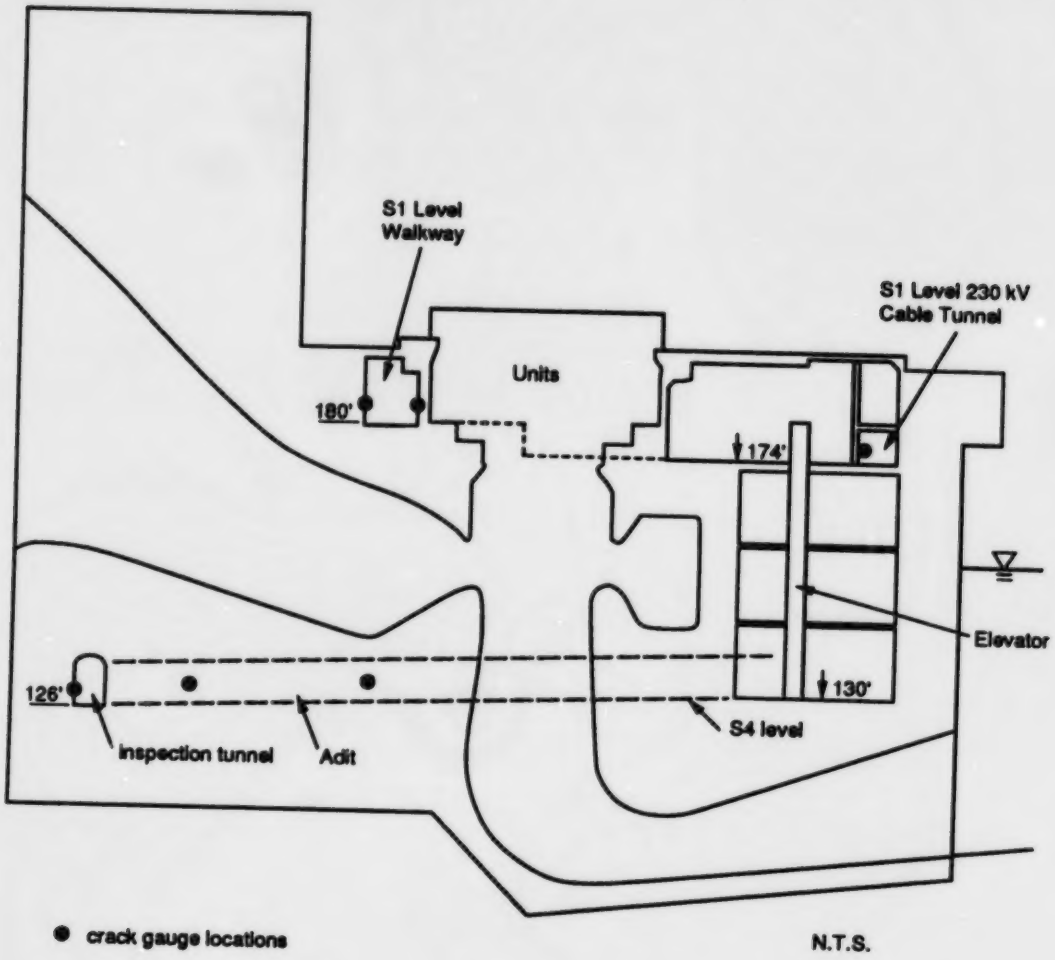
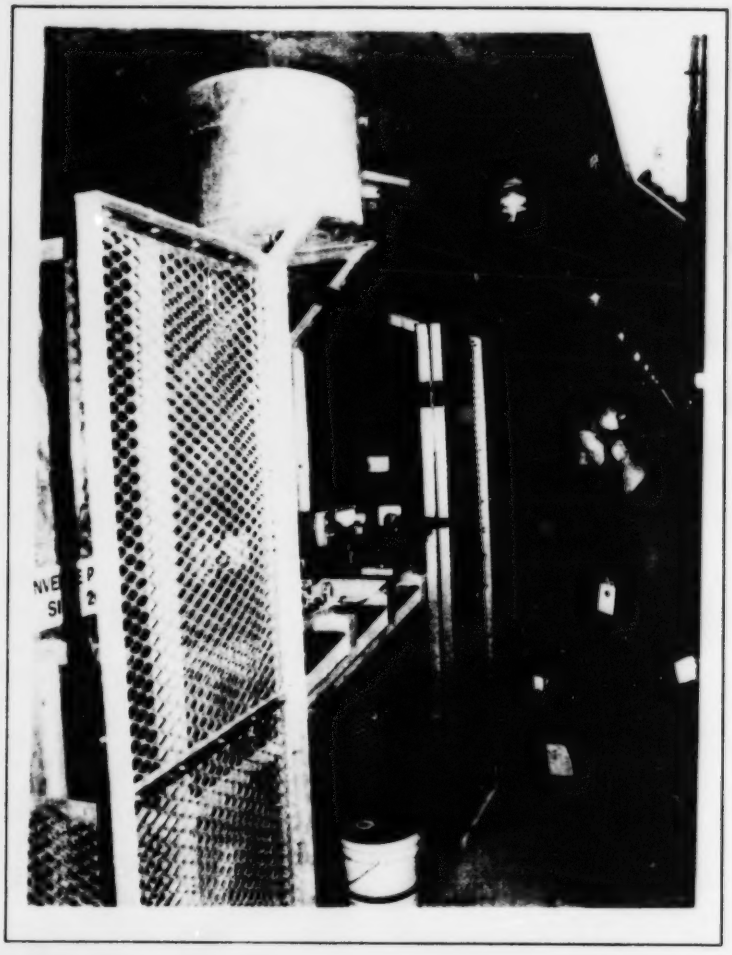


FIGURE 12

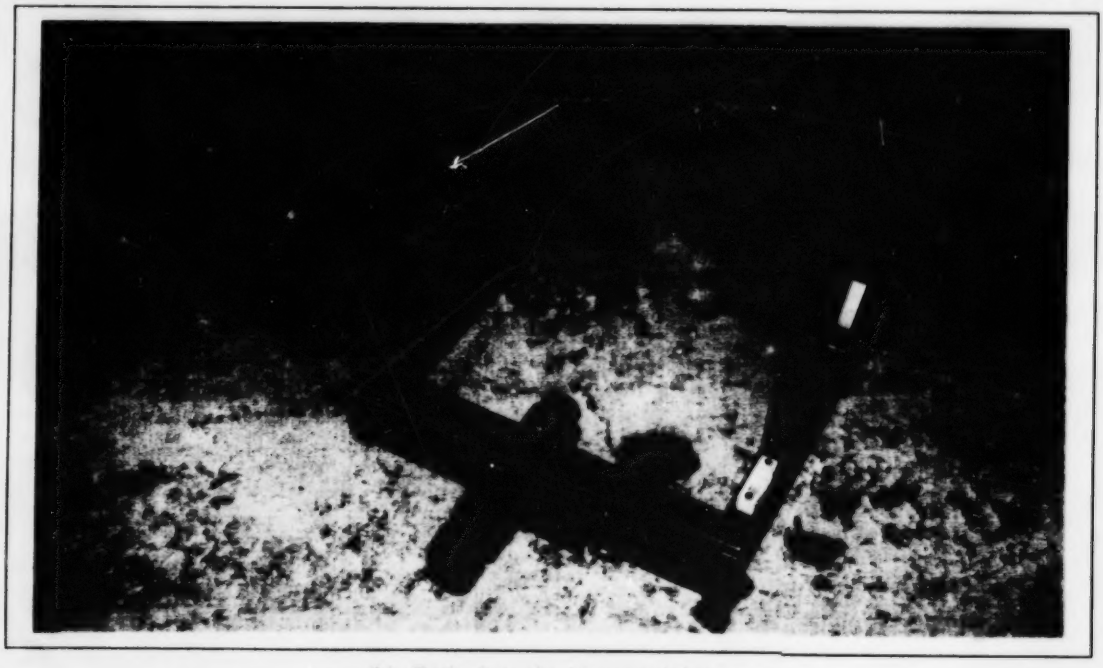
SECTION OF R.H. SAUNDERS G.S. SHOWING UNIT 4 PENDULUM LOCATIONS

91-132

185241 RD-AF41



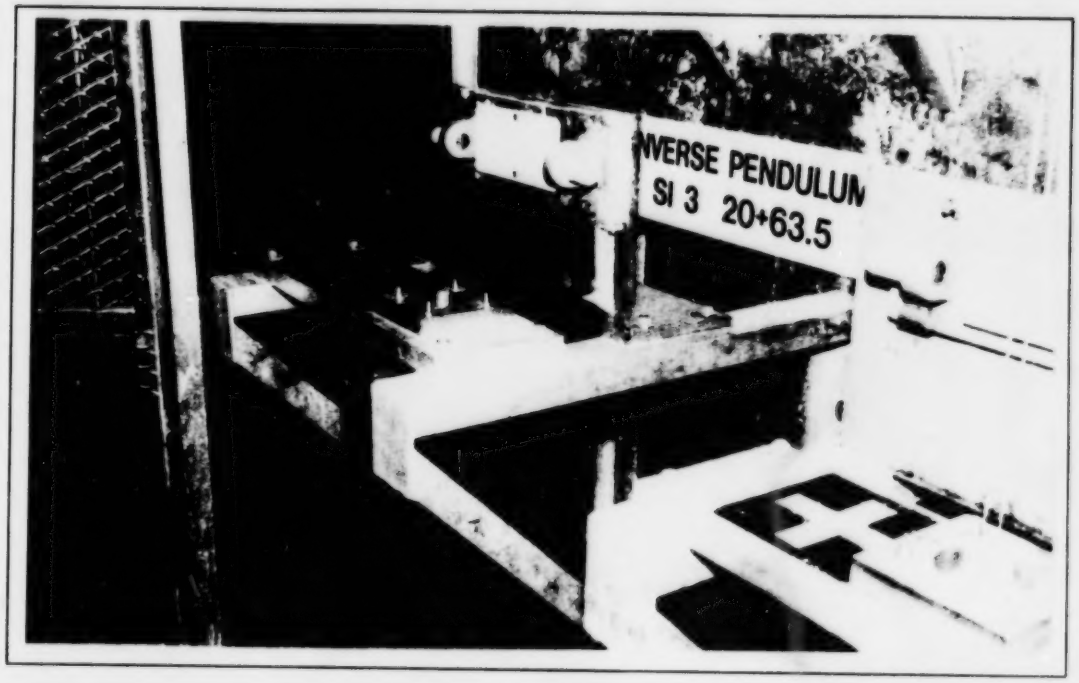
(a) Normal and inverse pendulums previously installed at Unit 6 and Unit 12



(b) Optical readout for pendulums

FIGURE 13

91-132
185994-B35-RD



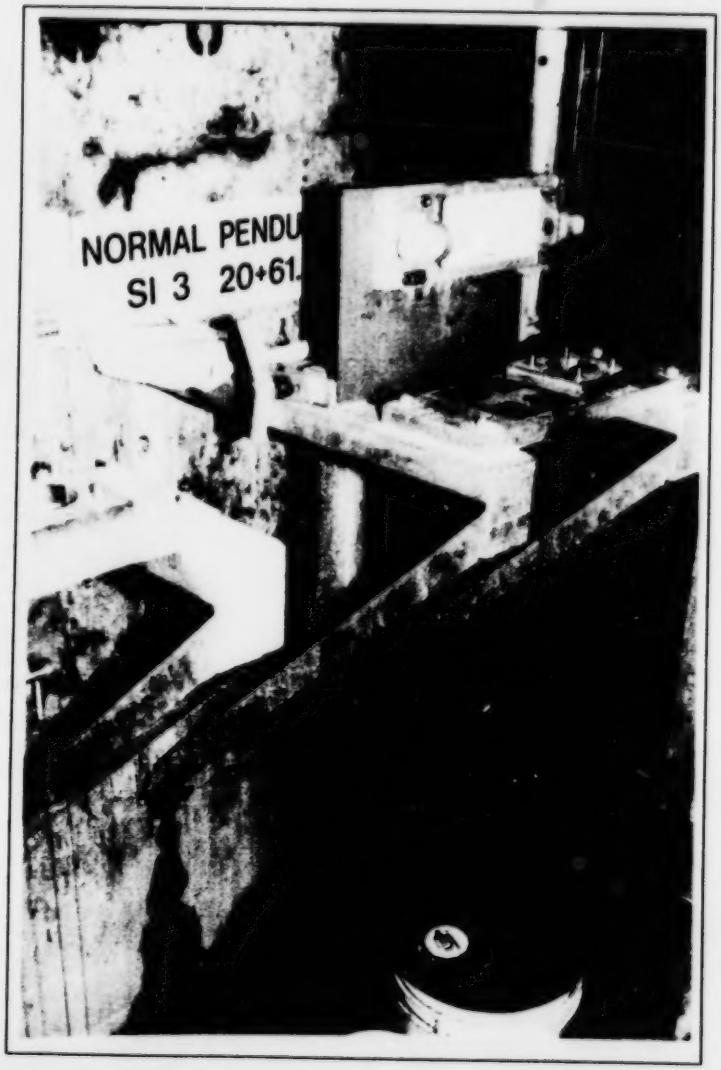


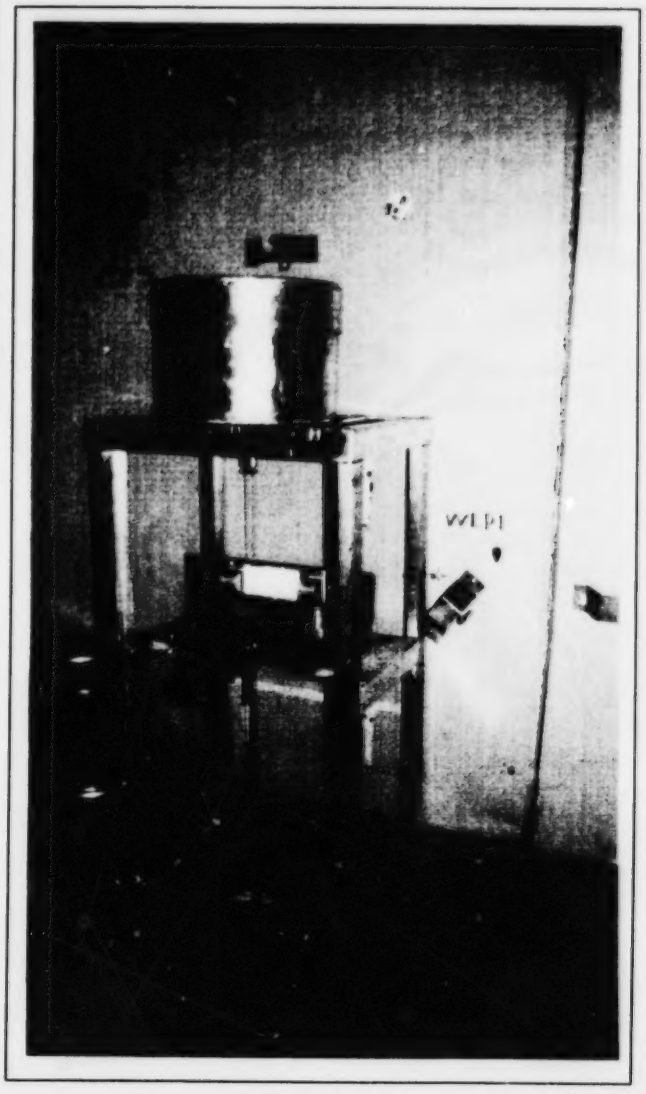
FIGURE 14

NORMAL AND INVERSE PENDULUMS ON LEVEL S4 PREVIOUSLY INSTALLED AT UNIT 6 AND 12

91-132
185995-B34-RD

(a) Normal pendulum drilled from headworks to Level S4 in Inspection Tunnel

NQ borehole length 121 ft.



(b) Inverse pendulum drilled through successive Levels S1, S2, S3 and S4, into bedrock (nominal elevation 88.75 ft)

FIGURE 15

(a) Normal pendulum installed in stairwell near Unit 4 from Level S1 to S4

(b) Pendulum wire attached to anchor plate on Level S1
Pendulum wire cased with PVC pipe in stairwell

FIGURE 16

91-132
185997-B35-RD

(a) Reading position of pendulum wire with optical readout

(b) Reading invar wire with depth micrometer

FIGURE 17

PENDULUM READINGS BY SOIL SCIENCES SECTION, CIVIL RESEARCH

91-132
185998-B35-RD

FIGURE 18

AUTOCENTERING READINGS
TAKEN BY SOIL SCIENCES SECTION,
CIVIL RESEARCH

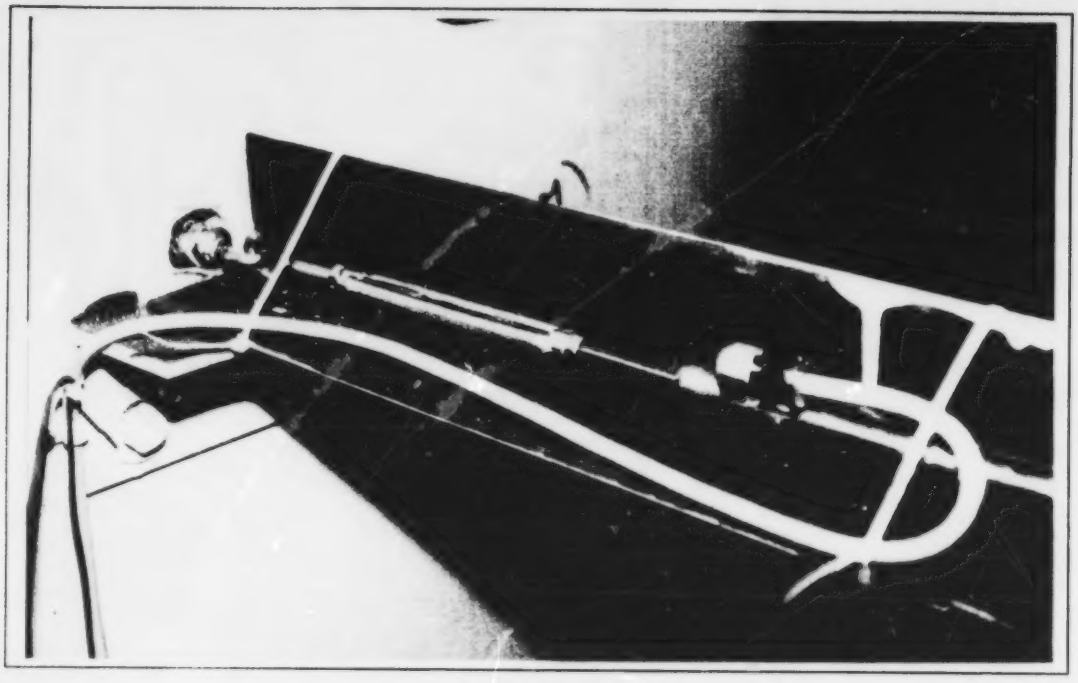


FIGURE 19

VIBRATING WIRE EXTENSOMETERS INSTALLED ACROSS UNIT 4 ON LEVEL S1 ON THE EAST AND WEST SIDES (SEE FIGURE 3)

Note: Extensometer anchored above major cracks on upstream wall

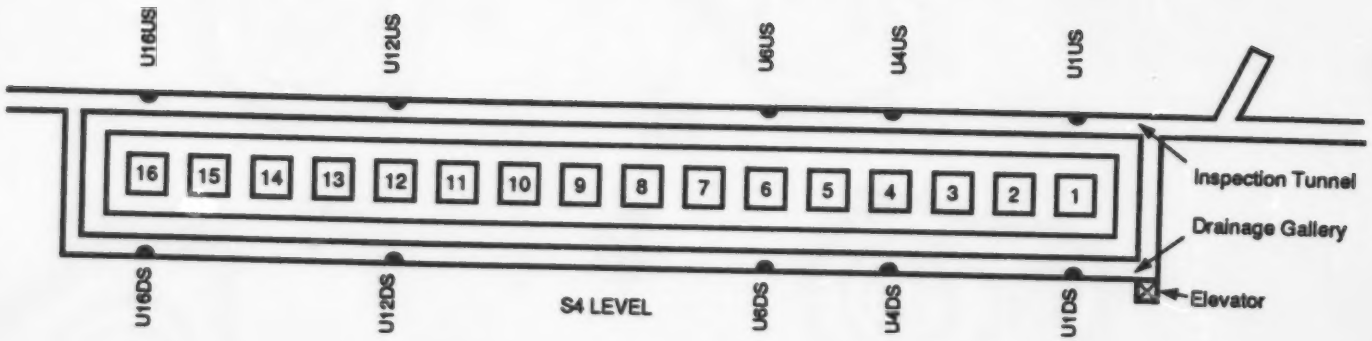
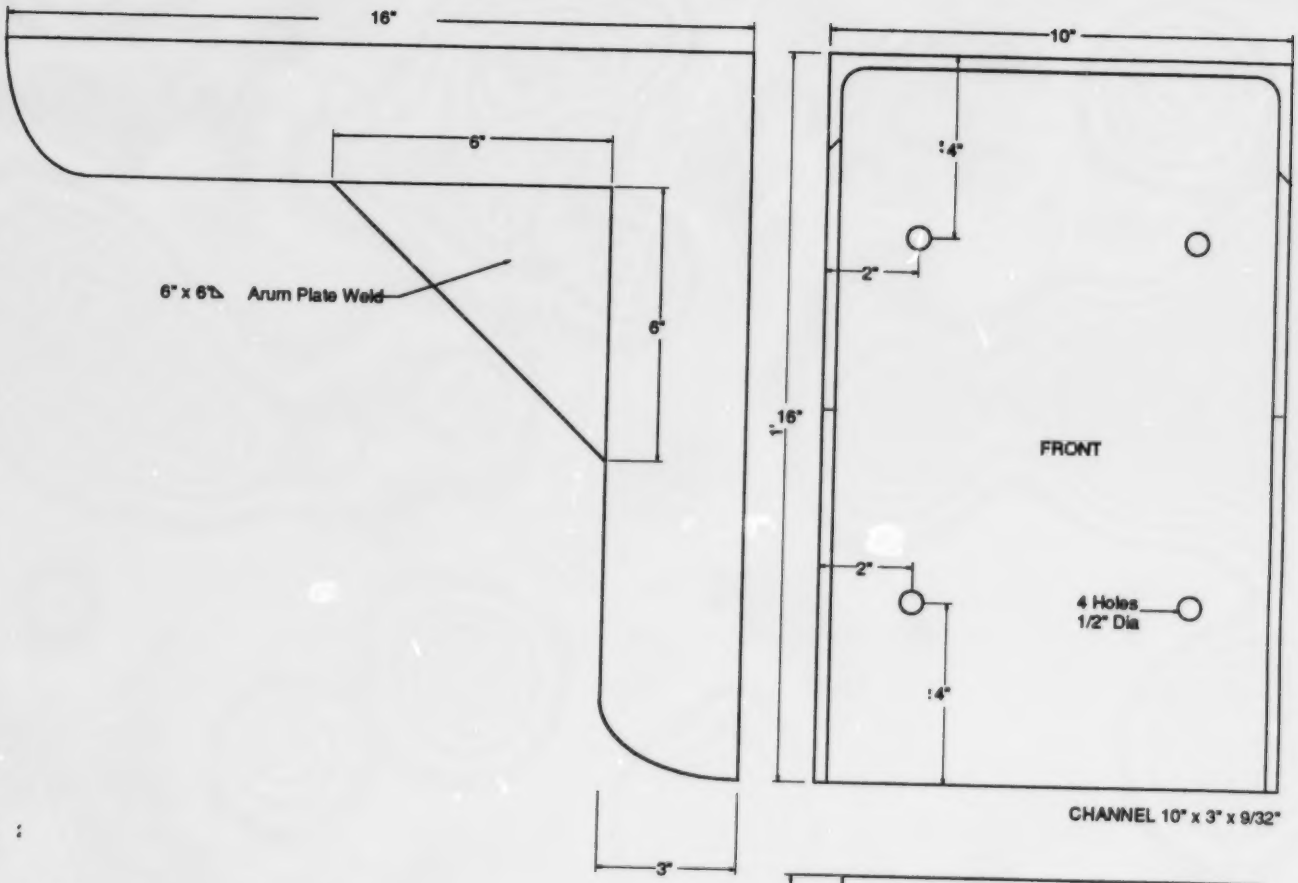


FIGURE 20

R.H. SAUNDERS G.S. - FORCED CENTERING PLATE LOCATIONS S4 LEVEL



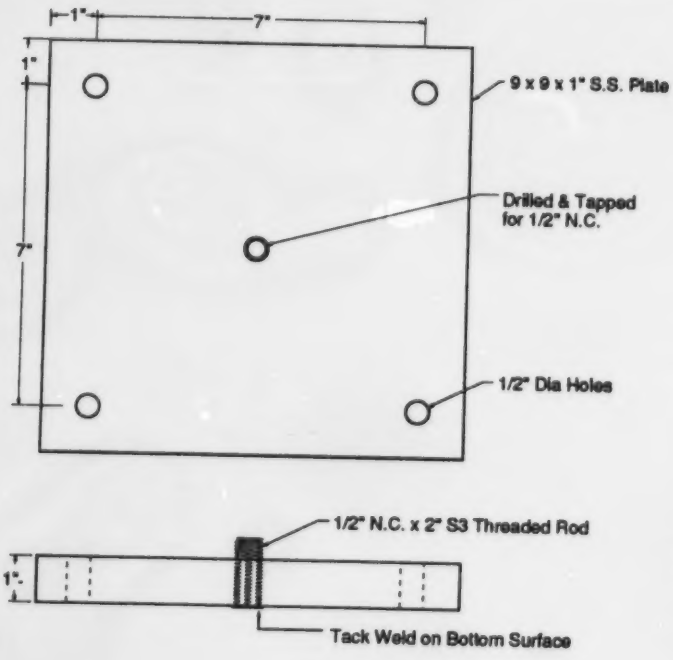


FIGURE 21(a)

R.H. SAUNDERS G.S. - FORCED CENTERING PLATES

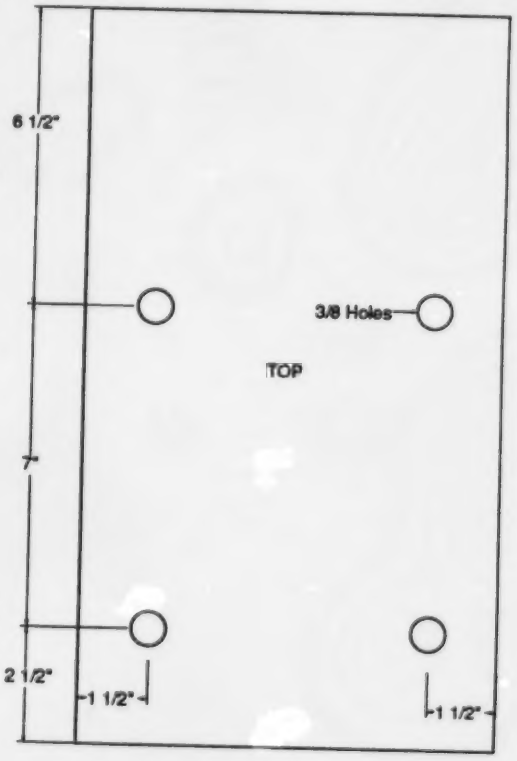


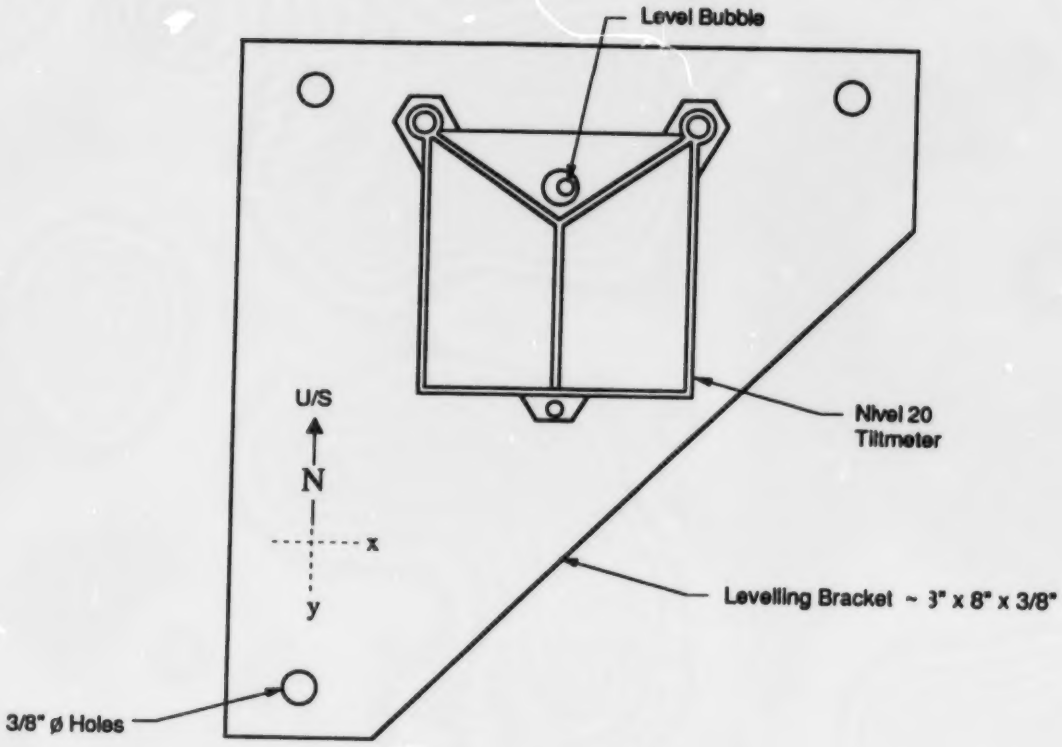
FIGURE 21(b)

R.H. SAUNDERS G.S. - FORCED CENTERING PLATES
-MOUNTING BRACKET

91-132

FIGURE 22

TELLUROMETER MA 2000
USED FOR ACCURATE DISTANCE
MEASUREMENT BY THE CIVIL
MAINTENANCE DEPT.
THE DEVICE WAS MOUNTED TO
THE FORCE CENTERING PLATE
PLATEFORM ON LEVEL S4
THROUGHOUT THE GENERATING
STATION.



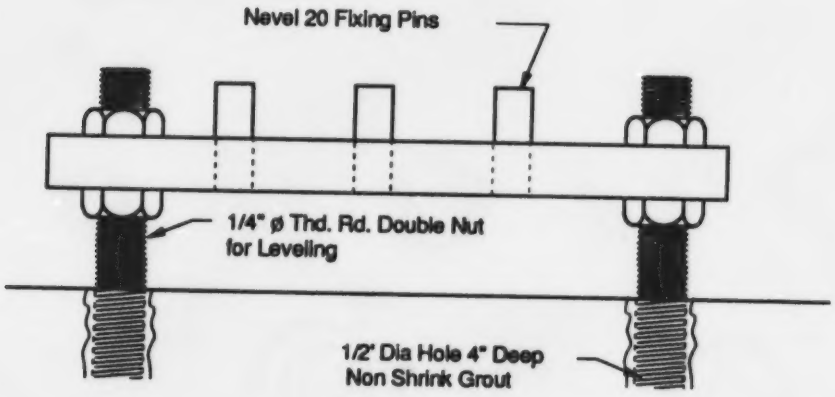


FIGURE 23

R.H. SAUNDERS G.S. - KERNSWISS NIVEL 20 TILMETERS

91-132
185726-G42-RD

(a) Levelling bracket was anchored to floor slab on Level S4, Unit 4

(b) Automatic data logger to record data from the tilt meter by Civil Maintenance Dept.

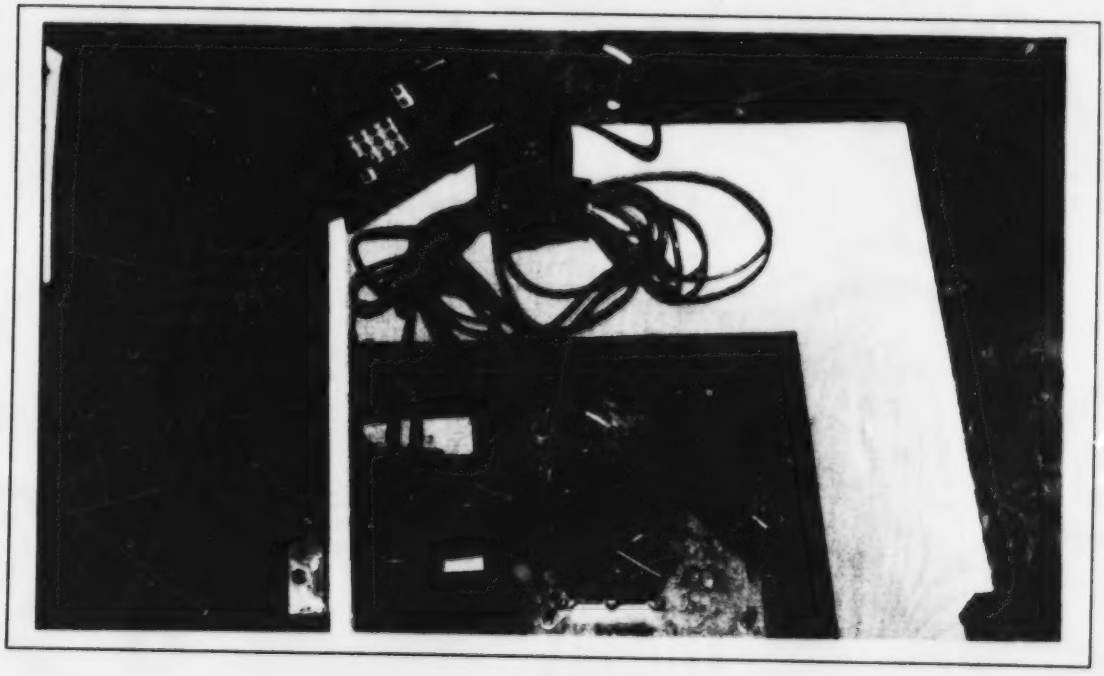
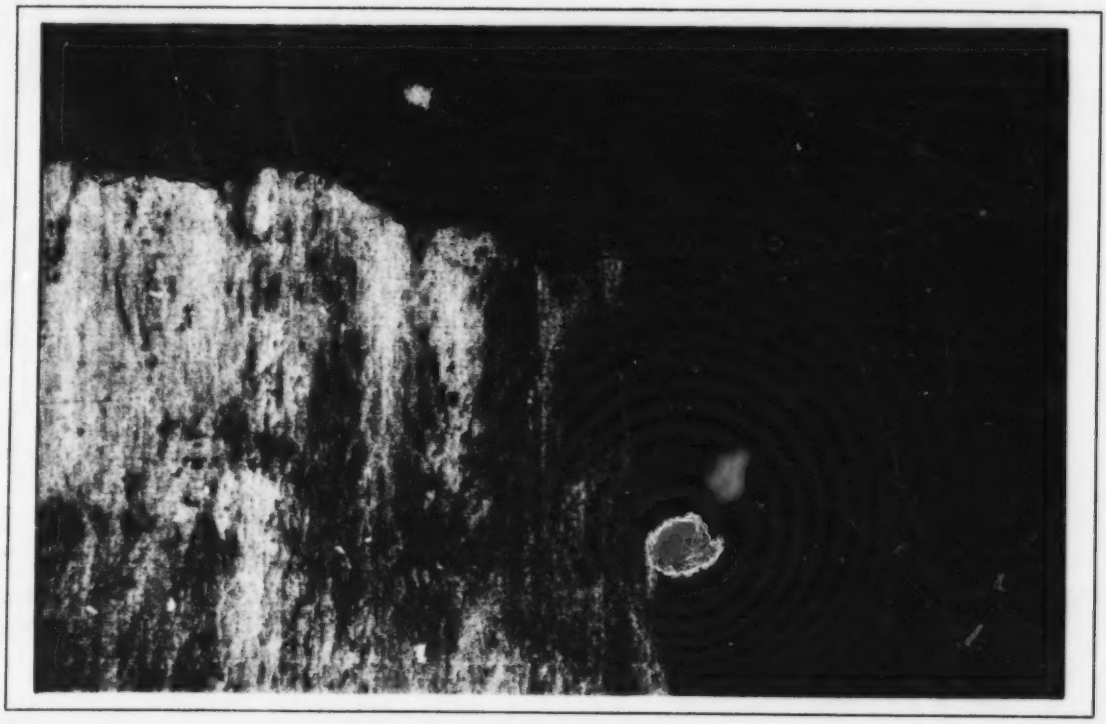


FIGURE 24

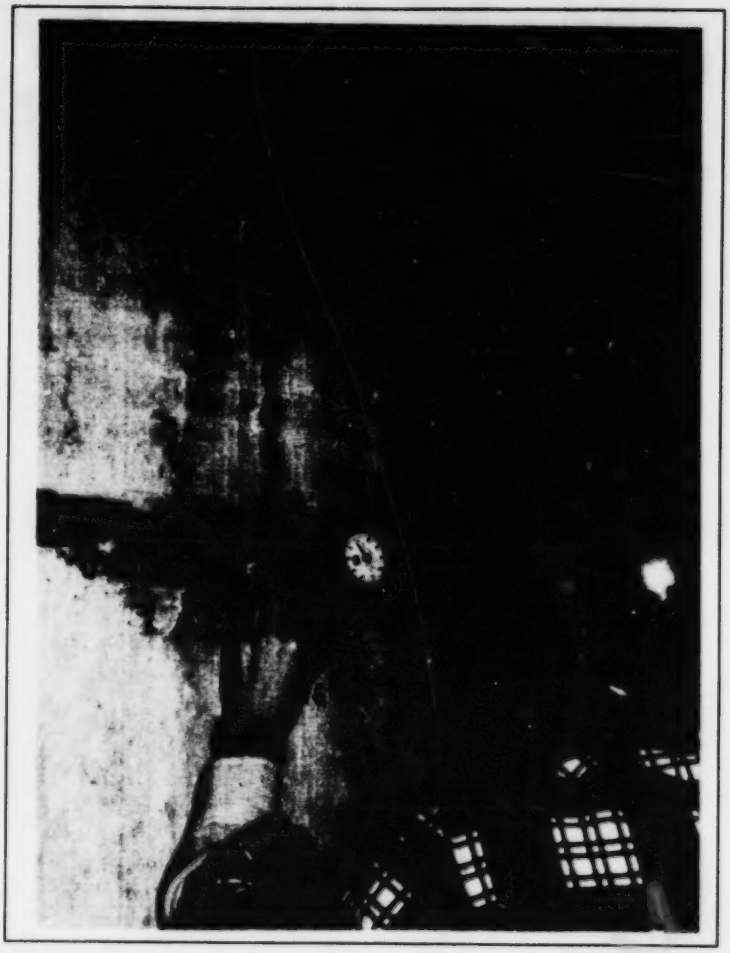
(a) Huggenberger Gauge (6 pts. A, B, C, D, E, F)



(b) Crack Meter

FIGURE 25

CRACK METERS



(a) Huggenberger crack gauge measured during load testing by Civil Maintenance Dept.

(b) Typical Huggenberger crack gauge arrangement spanning a crack/joint in concrete

FIGURE 26

APPENDIX A

Operator's Log Book
March 1 to March 10, 1991

done 1 OF 2

inter—office memo

to: DR. A. DANAY
H17G27

from: D.A. McKAY
CIVIL RESEARCH

subject: G-4 SHUTDOWN SCHEDULE

date: 11/3/91

file:

message:

The following schedule of activities during the March 2-10 shutdown of G-4 at R.H. Saunders GS was taken from the operator's log book.

SATURDAY MARCH 2

05:00 - unit shutdown

08:50 - start placing logs in tail race

13:22 - all logs in tail race

13:30 - de-watering pumps started
- water tight seal not achieved

SUNDAY MARCH 3

14:50 - 4TH Log installed in A gain, tail race in attempt to get proper water seal

17:25 - unit pumped out

FRIDAY MARCH 8

17:42 - draft tube water up started, requires approximately three (3) hours to complete

SATURDAY MARCH 9

08:30 - one tail race log pulled from C gain
- start of unit priming

11:05 - all stop logs removed from tail race

11:35 - unit primed and ready - actually ready at about 11:

19:00 - unit on

SUNDAY MARCH 10

10:01 - load rejection, complete unit

inter--office memo

to: DR. A. DANAY H17 G-27

from: DA MCKAY CIVIL RESEARCH

subject: G-4 SHUTDOWN SCHEDULE

date: 11/3/91

file:

message:

- complete unit 4 shutdown, load switch to unit 3 causes power spike that destroys microchips in two test gauges
10:58 - unit back on line
10:59 - unit synchronized to bus and back in service 48 hours ahead of original plan

NOTE: MECH RESEARCH had the unit turned at approx 17:05 on 8/3/91 to calibrate their proximity probes. A response by the on line strain gauges may have been caused by the closing of the draft tube hatchway creating a buildup of air pressure in the unit. This information came from the MECH MTCE crew.

91-132

APPENDIX B

Drill Logs and Borehole Aligment Corrections

(i) for Normal Pendulum, Unit 4

(ii) for Inverse Pendulum, Unit 4

R.H. SAUNDERS - NORMAL PENDULUM

UNIT 4

DEPTH (ft)	NORTH	DIFF (mm)	EAST	DIFF (mm)
0	32.7		14.7	
8 8 mm	32.2 32.5	-5 -2	14.0 14.8	-7 +1
15'6	32.4	-3	14.3	-4
21' 8 mm	31.8 32.6	-9 -1	14.3 14.7	-4 0
23 8 mm	31.5 32.1	-12 -6	14.0 14.3	-7 -4
26 10 mm	31.8 32.4	-9 -3	13.9 14.6	-8 -1
33 40	33.3 34.0	+6 +13	14.8 15.0	+1 +3
49 Steel in hole 51 (8 mm)	33.5 32.8	+8 +1	15.2 14.6	+5 -1
58 63 8 mm	32.3 32.0 32.5	-4 -7 -2	14.5 14.0 14.8	-2 -7 +1
70'2 75'5	32.2 32.0	-5 -7	14.8 15.0	+1 +3
80 80	31.7 32.5	-10 -2	15.5 15.0	+8 +3
87'9 92'11 98'0 98'0 8 mm 105 110'5 115'8	32.7 33.2 33.4 32.8 33.3 33.3 33.4	0 +5 +7 +1 +6 +6 +7	15.1 15.3 15.5 14.9 15.2 14.81 14.4	+4 +6 +8 +2 +5 +1 -3

241992
new 86-03

Geotechnical & Hydraulic Engineering Department

drilling inspector's log - soil

date	site: R.H. Saunders GS	datum el.	hole no.
date started: December 18/90	location: Headworks - Unit 4 6' South of crane rail 3' West of Const. Joint	water el.	
date finished		ground el.	
dip	type of hole: Normal Pendulum	bedrock el.	sheet no.
bearing	water level	bottom el.	

sample number	depth from	depth to	blows	recovery	detailed description and remarks
	0	7'9			Short runs with NQ starter barrel
					Breaks at 1'2, 1'8, 1'11, 2'2, 2'4, 2'7,
					2'9, 3', 3'3, 3'5, 3'8, 3'9, 3'10, 3'11, 4', 4'2,
					4'3, 4'9, 5', 5'3, 5'8, 5'11, 6'5, 6'10, 6'11, 7'2, 7'7
	7'9	10'0			8 mm correction, E core and F.F. bit remaining to 10'0.
	10'0	15'6			NQ, breaks at 10'5, 11', 11'10, 12', 12'2,
					12'5, 12'8, 13'3, 13'6, 14', 14'2, 14'4, 14'8
					Rebar at 14'8, 14'9, 15'6
	15'6	20'9			NQ, breaks at 15'8, 16'1, 16'6, 17', 17'5,
					17'7, 18'1, 18'9
	20'9	22'9			8 mm correction, E core and F.F. bit to 22'9
	22'9	26'0			NQ, breaks at 23', 23'4, 23'9, 24'1, 24'9, 25'3, 26'
	26'0	28'0			10 mm correction, E core & F.F. bit to 28'0
	28'0	33'0			NQ, breaks at 28'4, 28'7, 29'8, 28'9, 28'11,
					29'2, 29'10, 30'1, 30'4, 30'9, 31'0, 31'5, 31'10, 32',
					32'4, 33'0
	33'0	38'0			NQ, breaks at 33'3, 33'6, 34'4, 34'7, 34'9,
					35'0, 35'4, 35'8, 36'4, 36'9, 37'4, 37'8
	38'0	42'8			NQ, breaks at 38'9, 39'3, 39'11, 40'3, 40'8,
					41'0, 41'5, 41'6, 42'1, 42'8

..... cont'd)

inspector: Al Morton

91-132

241992
86.03

Geotechnical & Hydraulic Engineering Department

drilling inspector's log - soil

date	site: R.H. Saunders	datum el.	hole no.
date started	location	water el.	
date finished		ground el.	
dip	type of hole	bedrock el.	sheet no.
bearing	water level	bottom el.	

sample number	depth from	depth to	blows	recovery	detailed description and remarks
	42'8	48'0			NQ, breaks at 42'8, 43'8, 44', 44'9, 45'3,
					45'11, 46'4, 46'10, 47'0, rebar and ground core to
					48'0
	48'0	52'6			NQ core in concrete

inspector: Al Morton

241992
96 03

Geotechnical & Hydraulic Engineering Department

drilling inspector's log - soil

date: Jan 15/91	site: R.H. Saunders BS	datum el.	hole no.
date started	location: Normal Pendulum Unit 4, 6' South of crane rail 3' West of const joint	water el.	
date finished		ground el.	
dip	type of hole: NQ	bedrock el.	sheet no.
bearing	water level	bottom el.	

sample number	depth from	depth to	blows	recovery	detailed description and remarks
	52'6	58'0			Steel in hole at approximately 49' correct to 51',
					8 mm E core and F.F. bit to 52'6
					NQ core, breaks at 53'5, 54'7, rebar at 54'4, 55'1,
					56', drilling to 57'3, 57'7, 57'10
	58'0	63'0			NW core, breaks at 59', 60'3, 60'10, 62'1, 62'7, 62'10
	63'0	65'0			8 mm correction, E core & F.F. bit to 65'0
	65'0	70'2			NQ core, breaks at 66'2, 67'7, 69', 69'6, 69'11, 70'2
	70'2	75'0			NQ core, breaks at 70'6, 71'6, 71'11, 72'1, 72'6, 72'8,
					73'5, 73'10, 74'5, 75'2, 76', 76'6, 76'9, 76'11, 77,
					77'6, 78', 78'3, 79'7, 80'4
	80'4	82'4			10 mm correction, E core & F.F. bit to 82'4
	82'4	87'9			NQ core in concrete
	87'9	92'11			NQ core in concrete
	82'11	98'0			NQ core in concrete
	98'0	100'0			8 mm correction, F.F. bit to 100'0
	100'0	105'			NQ core in concrete
	105'0	110'5			NQ core in concrete
	110'5	115'8			NQ core in concrete
	115'8	121'0			NQ core in concrete

inspector: Al Morton

R.H. SAUNDERS GS INVERSE PENDULUM

UNIT 4

DEPTH	N/S	DIFF	E/W	DIFF
DATUM 4'	37.9	0	15.7	0
6	38.0	+1	15.8	+1
8'6 8 mm	37.3 37.9	-6 0	16.0 15.9	+3 +2
13	36.6 37.4	-13 -5	16.4 16.2	+7 +5
16'4 Wire touching NQ rods,ream hole to 18'0 at NQ size, use special HQ 20 mm template	36.0 Wire touching NQ rods, ream hole to 18'0 at NQ size, use special HQ 20 mm template	-19 Wire touching NQ rods, ream hole to 18'0 at NQ size, use special HQ 20 mm template	18.0 Wire touching NQ rods, ream hole to 18'0 at NQ size, use special HQ 20 mm template	+13 Wire touching NQ rods, ream hole to 18'0 at NQ size, use special HQ 20 mm template
18'0 20 mm	36.8	-11	15.8	-1
20' 10 mm	35.8 37.0	-21 -9	16.0 15.9	+3 +2
22'6 10 mm Reamed hole HQ to 22'6 due to recurring N/S pattern	36.6 37.5 Reamed hole HQ to 22'6 due to recurring N/S pattern	-13 -4 Reamed hole HQ to 22'6 due to recurring N/S pattern	15.7 15.7 Reamed hole HQ to 22'6 due to recurring N/S pattern	0 0 Reamed hole HQ to 22'6 due to recurring N/S pattern
25 8 mm 27 32 34'6 8 mm 41 43'8 mm	37.0 38.0 37.7 38.6 39.0 38.3 39.0 38.2	-9 +1 -2 +7 +11 +4 +11 +3	16.0 15.7 16.1 16.1 16.0 15.9 16.1 15.7	+3 0 +4 +4 +3 +2 +4 0

END OF HOLE 43', anchor point 41'4" below 130' elevation

Geotechnical & Hydraulic Engineering Department

drilling inspector's log - soil

date: Dec 6/90	site: R.H. Saunders GS	datum el.: 130'	hole no.
date started	location: S4 elev. gallery 30" from cont. joint 18" U/S from wall	water el.	
date finished		ground el.	
dip	type of hole: NQ inverse pendulum	bedrock el.	sheet no.
bearing	water level	bottom el.	

sample number	depth from	depth to	blows	recovery	detailed description and remarks
					Run NW casing through bottom of gutter
					16" into concrete. Gutter base is 30: below floor.
					All measurements relative to floor.
	3'10	7'2			NW casing to 3'10, NQ starter barrel to 7'2, rebar
					at 4', breaks at 3'10, 4', 4'7, 5'1, 5'3, 5'7, 5'10, 7'2.
	7'2	10'8			NW barrel, breaks at 9;9, 10'8, hole very crooked,
					10 mm template, E core to 12'8
	12'8	15'3			Reamed to 12'8, NQ core to 15'3, breaks at 13'4,
					13'10, 14'4, 15'3. Hole very crooked, set 10 mm
					template, unable to correct, grouted hole to surface
					with quik plug/normal port. Mix and allowed to set
					over weekend.
					Drilled out grout to (zero) 4', measured - OK
					NQ to 6', OK, NQ to 8'6, 8 mm correction, E core
					and remaining to 10'6.
					Attempted grouting with Quik Plug^2, set 45-twice.
					Finally reamed hole to HQ size to 18'0, 20 mm correction
					E core 18'0-20'0

inspector: Al Morton

241992
86-03

Geotechnical & Hydraulic Engineering Department

drilling inspector's log - soil

date: Jan 8/90	site: R.H. Saunders GS	datum el.: 130'	hole no.
date started	location: Inverse Pendulum S-4 Gallery 30" from const joint 18" from wall	water el.	
date finished		ground el.	
dip	type of hole: NQ	bedrock el.	sheet no.
bearing	water level	bottom el.	

sample number	depth from	depth to	blows	recovery	detailed description and remarks
					F.F. bit reaming to 20'0
	20'0	22'6			10 mm correction, E core to 22'6, F.F. bit to 22'6
	22'6	25'0			10 mm correction, E core and F.F. bit to 25'0
					reamed hole to HQ to 22'6
	25'0	27'0			8 mm correction
	27'0	32'0			NQ core
	32'0	34'6			NQ core
					8 mm correction, E core to 36'6
	36'6	41'0			NQ core 36'6 to 41'0
					Bedrock contact 38'8
	41'0	43'0			8 mm correction,E core to 43'0

inspector: Al Morton

91-132

APPENDIX C

Normal Pendulum (19 + 03)
Autocentering Readings, Unit 4

R.H.Saunders Generating Station Mar 9/91
Normal Pendulum Datum Auto Center
Unit 4 Watered 2:00 to 4:30 pm

Depth (m)	Depth Ft	N/S (mm)	E/W (mm)		ABSOLUTE POSITION N/S (mm)	E/W (mm)
		23.42	88.47	without AC device		
0.00						
1.83	6					
2.44	8	26.86	93.38		3.24	4.91
3.05	10					
3.66	12	26.47	95.18		5.05	6.69
4.27	14					
4.88	16	29.04	92.53		5.62	4.08
5.49	18					
6.10	20	29.56	93.38		6.14	4.91
6.71	22					
7.32	24	26.36	94.59		2.94	6.12
7.92	26					
8.53	28	22.58	93.03		-0.84	4.58
9.14	30					
9.75	32	20.44	92.84		-2.98	4.17
10.36	34					
10.97	36	15.67	90.83		-7.75	2.36
11.58	38					
12.19	40	14.11	88.35		-9.31	-0.12
12.80	42					
13.41	44	15.14	84.57		-8.28	-3.90
14.02	46					
14.63	48	18.81	84.60		-4.61	-3.87
15.24	50					
15.85	52	20.43	87.47		-2.99	-1.00
16.46	54					
17.07	56	23.13	89.39		-0.29	0.92
17.68	58					
18.29	60	25.09	90.01		1.67	1.54
18.90	62					
19.51	64	28.19	89.26		4.77	0.79
20.12	66					
20.73	68	30.23	87.24		6.81	-1.23
21.34	70					
21.95	72	30.03	84.68		6.61	-3.79
22.56	74					
23.16	76	31.48	84.48		8.06	-3.99
23.77	78					

24.38	80	29.48	83.67	6.06	-4.80
24.99	82				
25.60	84	23.39	83.51	-0.03	-4.96
26.21	86				
26.82	88	18.64	82.81	-4.78	-5.66
27.43	90				
28.04	92	15.38	82.09	-8.04	-6.38
28.65	94				
29.26	96	15.38	80.78	-8.04	-7.71
29.87	98				
30.48	100	13.94	84.21	-9.48	-4.26
31.09	102				
31.70	104	15.71	87.31	-7.71	-1.16
32.31	106				
32.92	108	14.48	89.26	-8.94	0.81
33.53	110				
34.14	112	12.74	94.26	-10.68	5.79
34.75	114				
35.36	116	11.56	97.02	-11.86	8.55
35.97	118				
	120	15.68	98.48	-7.74	10.01

no adjustment required Reference Data

N/S +VE CHANGE TOWARDS SOUTH

E/W +VE CHANGE TOWARDS EAST

R.H.Saunders Generating Station Mar 7/91
Normal Pendulum Datum Auto Center
Unit 4 Dewatered 2:30 to 4:00 pm

Note using Mar 9 as reference with adjusted readings to compare between Mar 9 and Mar 7

Depth (m)	Depth Ft	N/S (mm)	E/W (mm)		ADJUSTED READINGS N/S (mm)	ADJUSTED READINGS E/W (mm)	ABSOLUTE POSITION N/S (mm)	ABSOLUTE POSITION E/W (mm)
		25.15	88.86	without AC device				
1.83	6							
2.44	8	26.09	92.54	ice particles falling dow	24.38	92.15	0.94	3.68
3.05	10							
3.66	12	27.85	94.55		26.12	94.18	2.70	5.69
4.27	14							
4.88	16	29.05	92.62		27.32	92.23	3.90	3.76
5.49	18							
6.10	20	29.74	93.24		28.01	92.85	4.59	4.38
6.71	22							
7.32	24	26.87	94.68		24.94	94.29	1.52	5.82
7.92	26							
8.53	28	22.92	92.81		21.19	92.42	-2.23	3.95
9.14	30							
9.75	32	20.56	92.70		18.83	92.31	-4.59	3.84
10.36	34							
10.97	36	16.03	90.66		14.30	90.27	-9.12	1.80
11.58	38							
12.19	40	14.41	88.32		12.68	87.93	-10.74	-0.54
12.80	42							
13.41	44	15.32	84.68		13.59	84.29	-9.83	-4.18
14.02	46							
14.63	48	19.02	84.67		17.29	84.28	-6.13	-4.19
15.24	50							
15.85	52	20.72	87.48		18.99	87.09	-4.43	-1.38
16.46	54							
17.07	56	23.26	89.35		21.53	88.96	-1.89	0.49
17.68	58							
18.29	60	25.18	90.10		23.45	89.71	0.03	1.24
18.90	62							
19.51	64	28.28	89.37		26.55	88.98	3.13	0.51
20.12	66							
20.73	68	30.45	87.10		28.72	86.71	5.30	-1.76
21.34	70							
21.95	72	29.93	84.73		28.20	84.34	4.78	-4.13
22.56	74							
23.16	76	31.42	84.56		29.69	84.17	6.27	-4.30
23.77	78							
24.38	80	29.51	83.64		27.78	83.25	4.38	-5.22

24.99	82		
25.60	84	23.53	83.45
26.21	86		
26.82	88	18.71	82.60
27.43	90		
28.04	92	15.37	82.34
28.65	94		
29.26	96	16.30	80.84
29.87	98		
30.48	100	14.06	84.29
31.09	102		
31.70	104	15.60	87.28
32.31	106		
32.92	108	14.60	89.29
33.53	110		
34.14	112	12.70	94.26
34.75	114		
35.36	116	11.48	98.91
35.97	118		
36.58	120	14.72	98.45

21.80	83.08	-1.82	-5.41
16.98	82.21	-6.44	-6.26
13.84	81.95	-9.78	-8.52
13.57	80.45	-9.86	-8.02
12.32	83.90	-11.10	-4.57
13.87	86.89	-9.55	-1.58
12.90	88.90	-10.52	0.43
10.97	93.87	-12.45	5.40
9.75	96.52	-13.67	8.05
12.99	98.08	-10.43	9.59

Note: Unit 4 is dewatered at 2:30pm

(Mar 1 full of water and Mar 7 is dewatered)

N/S +VE CHANGE TOWARDS SOUTH

E/W +VE CHANGE TOWARDS EAST

without AC device need to add -1.73 mm shift NS (for Mar9)

without AC device need to add -0.39 mm shift EW (for Mar9)

R.H.Saunders Generating Station Mar 3/91
Normal Pendulum Datum Auto Center
Unit 4 Dewatered 2:00 pm

Note using Mar 9 as reference with adjusted readings to compare between Mar 9 and Mar 3

Depth (m)	Depth Ft	N/S (mm)	E/W (mm)		ADJUSTED READINGS N/S (mm)	ADJUSTED READINGS E/W (mm)	ABSOLUTE POSITION N/S (mm)	ABSOLUTE POSITION E/W (mm)
		25.00	88.84	without AC device				
1.83	6							
2.44	8	27.01	93.69		25.43	93.32	2.01	4.85
3.05	10							
3.66	12	28.14	94.85		26.56	94.48	3.14	6.01
4.27	14							
4.88	16	28.92	92.51		27.34	92.14	3.92	3.67
5.49	18							
6.10	20	29.53	93.32		27.95	92.95	4.53	4.48
6.71	22							
7.32	24	28.51	94.63		24.93	94.26	1.51	5.79
7.92	26							
8.53	28	22.70	92.88		21.12	92.51	-2.30	4.04
9.14	30							
9.75	32	20.43	92.59		18.85	92.22	-4.57	3.75
10.36	34							
10.97	36	15.74	90.86		14.15	90.49	-9.26	2.02
11.58	38							
12.19	40	14.25	88.22		12.67	87.85	-10.75	-0.62
12.80	42							
13.41	44	15.32	84.54		13.74	84.17	-9.68	-4.30
14.02	46							
14.63	48	19.02	84.76		17.44	84.39	-5.98	-4.08
15.24	50							
15.85	52	20.85	87.51		19.07	87.14	-4.35	-1.33
16.46	54							
17.07	56	23.17	89.32		21.59	88.95	-1.83	0.48
17.68	58							
18.29	60	25.12	89.74		23.54	89.37	0.12	0.90
18.90	62							
19.51	64	28.21	89.17		26.63	88.80	3.21	0.33
20.12	66							
20.73	68	30.22	87.25		28.64	86.88	5.22	-1.59
21.34	70							
21.95	72	29.84	84.98		28.08	84.61	4.64	-3.86
22.56	74							
23.16	76	30.91	84.91		29.30	84.54	5.91	-3.93
23.77	78							
24.38	80	28.86	83.94		27.37	83.57	3.96	-4.90

24.99	82		
25.60	84	23.26	83.58
26.21	86		
26.82	88	18.52	82.88
27.43	90		
28.04	92	15.14	82.09
28.65	94		
29.26	96	15.39	80.65
29.87	98		
30.48	100	14.26	83.90
31.09	102		
31.70	104	15.91	87.01
32.31	106		
32.92	108	14.79	88.89
33.53	110		
34.14	112	12.88	94.58
34.75	114		
35.36	116	12.26	96.40
35.97	118		
36.58	120	14.14	97.75

21.70	83.22	-1.72	-5.25
18.94	82.29	-6.48	-6.18
13.56	81.72	-9.88	-6.75
13.81	80.28	-9.61	-8.19
12.68	83.53	-10.74	-4.94
14.33	86.84	-9.09	-1.83
13.21	88.52	-10.21	0.05
11.30	94.21	-12.12	5.74
10.88	98.03	-12.74	7.56
12.58	97.38	-10.86	8.91

Note: Unit 4 was dewatered at 2:30pm

(Mar 1 full of water and Mar 7 is dewatered)

N/S +VE CHANGE TOWARDS SOUTH

E/W +VE CHANGE TOWARDS EAST

without AC device need to add -1.58 mm shift NS (for Mar9)

without AC device need to add -0.37 mm shift EW (for Mar9)

R.H.Saunders Generating Station Mar 1/91
Normal Pendulum Datum Auto Center
Unit 4

Note using Mar 9 as reference with adjusted readings to compare between Mar 9 and Mar 1

Depth (m)	Depth Ft	N/S (mm)	E/W (mm)		ADJUSTED READINGS N/S (mm)	ADJUSTED READINGS E/W (mm)	ABSOLUTE POSITION N/S (mm)	ABSOLUTE POSITION E/W (mm)
		24.76	88.38	without AC device				
1.83	6							
2.44	8	26.60	93.68		25.07	93.58	1.85	5.11
3.05	10							
3.66	12	28.07	94.28		26.54	94.18	3.12	5.71
4.27	14							
4.88	16	29.08	92.28		27.55	92.18	4.13	3.71
5.49	18							
6.10	20	29.73	93.17		28.20	93.07	4.78	4.60
6.71	22							
7.32	24	26.63	94.48		25.10	94.38	1.88	5.91
7.92	26							
8.53	28	22.76	92.86		21.23	92.76	-2.19	4.29
9.14	30							
9.75	32	20.57	92.54		19.04	92.44	-4.38	3.97
10.36	34							
10.97	36	15.86	90.69		14.33	90.59	-9.09	2.12
11.58	38							
12.19	40	14.39	88.17		12.86	88.07	-10.56	-0.40
12.80	42							
13.41	44	15.43	84.47		13.90	84.37	-9.52	-4.10
14.02	46							
14.63	48	19.03	84.67		17.50	84.57	-5.92	-3.90
15.24	50							
15.85	52	20.43	87.32		18.90	87.22	-4.52	-1.25
16.46	54							
17.07	56	23.12	89.55		21.59	89.45	-1.83	0.98
17.68	58							
18.29	60	25.17	89.96		23.64	89.86	0.22	1.39
18.90	62							
19.51	64	27.83	90.12		26.30	90.02	2.88	1.55
20.12	66							
20.73	68	30.11	87.73		28.58	87.63	5.16	-0.84
21.34	70							
21.95	72	29.80	85.53		28.07	85.43	4.65	-3.04
22.56	74							
23.16	76	31.30	85.24		29.77	85.14	6.35	-3.33
23.77	78							
24.38	80	29.26	84.20		27.73	84.10	4.31	-4.37

24.99	82						
25.60	84	23.76	83.21	22.23	83.11	-1.19	-5.36
26.21	86						
26.82	88	18.38	83.09	18.83	82.99	-6.50	-5.48
27.43	90						
28.04	92	15.21	82.15	13.88	82.06	-9.74	-6.42
28.65	94						
29.26	96	15.47	80.96	13.94	80.86	-9.48	-7.61
29.87	98						
30.48	100	14.63	83.93	13.10	83.83	-10.32	-4.64
31.09	102						
31.70	104	15.57	87.65	14.04	87.55	-9.38	-0.92
32.31	106						
32.92	108	15.45	88.82	13.92	88.72	-9.50	0.25
33.53	110						
34.14	112	14.39	92.91	12.86	92.81	-10.56	4.34
34.75	114						
35.36	116	12.76	95.79	11.23	95.69	-12.19	7.22
35.97	118						
36.58	120	14.48	97.23	12.95	97.13	-10.47	8.66

without AC device need to add -1.53 mm shift NS (for Mar9)

without AC device need to add -0.10 mm shift EW (for Mar9)

Note: Depth from top of headworks

Invar wire damaged while removing ice from casing

at deck level. New zero readings taken for pendulum and invar on Mar 3.

Pendulum wire was re-positioned while installing new invar wire.

N/S +VE CHANGE TOWARDS SOUTH

E/W +VE CHANGE TOWARDS EAST

R.H.Saunders Generating Station Feb 14/91
Normal Pendulum Datum Auto Center
Unit 4

Note using Mar 9 as reference with adjusted readings to compare between Mar 9 and Feb14

Depth (m)	Depth (ft)	N/S (mm)	E/W (mm)		ADJUSTED READINGS N/S (mm)	ADJUSTED READINGS E/W (mm)	ABSOLUTE N/S (mm)	POSITION E/W (mm)
		24.96	88.66	without AC device				
1.83	6	26.91	91.51		25.36	91.32	1.93	2.85
2.44	8	26.62	92.96		25.08	92.79	1.64	4.32
3.05	10	27.12	93.99		25.58	93.80	2.14	5.33
3.66	12	28.00	94.42		26.44	94.23	3.02	5.76
4.27	14	28.91	94.36		27.35	94.17	3.93	5.70
4.88	16	28.96	93.74		27.40	93.55	3.98	5.08
5.49	18	29.55	92.78		27.99	92.59	4.57	4.12
6.10	20	29.62	93.87		28.06	93.68	4.64	5.21
6.71	22	27.99	95.11		26.43	94.92	3.01	6.45
7.32	24	27.13	94.89		25.57	94.70	2.15	6.23
7.92	26	24.39	93.74		22.83	93.55	-0.59	5.08
8.53	28	21.90	92.89		20.24	92.70	-3.18	4.23
9.14	30	20.10	92.60		18.54	92.41	-4.88	3.94
9.75	32	19.89	92.39		18.33	92.20	-5.09	3.73
10.36	34	16.36	91.58		14.80	91.39	-8.62	2.92
10.97	36	13.96	90.65		12.39	90.46	-11.03	1.99
11.58	38	13.12	89.72		11.56	89.53	-11.86	1.06
12.19	40	12.85	88.10		11.08	87.91	-12.33	-0.56
12.80	42	12.58	86.02		11.02	85.83	-12.40	-2.64
13.41	44	13.87	84.30		12.31	84.11	-11.11	-4.36
14.02	46	15.83	83.94		14.27	83.75	-9.15	-4.72
14.63	48	17.57	84.23		16.01	84.04	-7.41	-4.43
15.24	50	18.99	85.09		17.43	84.90	-5.99	-3.57
15.85	52	19.77	86.34		18.21	86.15	-5.21	-2.32
16.46	54	20.74	87.83		19.18	87.74	-4.24	-0.73
17.07	56	21.76	89.06		20.20	88.86	-3.22	0.39
17.68	58	22.53	89.58		20.97	89.39	-2.45	0.92
18.29	60	23.65	89.76		22.09	89.57	-1.33	1.10
18.90	62	25.18	89.70		23.60	89.51	0.18	1.04
19.51	64	26.80	89.32		25.24	89.13	1.82	0.66
20.12	66	26.31	88.21		26.75	88.02	3.33	-0.45
20.73	68	26.94	87.05		27.38	86.86	3.96	-1.61
21.34	70	26.96	86.08		27.40	85.89	3.98	-2.58
21.95	72	26.32	84.89		26.76	84.50	3.34	-3.97
22.56	74	29.05	84.15		27.49	83.96	4.07	-4.51
23.16	76	29.86	84.36		28.30	84.17	4.88	-4.30
23.77	78	28.78	84.29		27.22	84.10	3.80	-4.37
24.38	80	27.50	83.87		25.94	83.68	2.52	-4.79

24.99	82	24.76	83.66
25.60	84	21.13	83.38
26.21	86	18.44	82.99
26.82	88	16.91	82.43
27.43	90	15.30	82.30
28.04	92	13.98	81.27
28.65	94	13.87	80.23
29.26	96	14.18	79.79
29.87	98	13.48	80.82
30.48	100	12.71	82.74
31.09	102	14.34	85.51
31.70	104	14.53	86.33
32.31	106	14.32	87.22
32.92	108	13.03	87.97
33.53	110	12.50	89.91
34.14	112	11.45	92.31
34.75	114	11.38	94.65
35.36	116	9.97	95.76
35.97	118	8.26	97.20
36.58	120	14.43	97.05

23.20	83.47	-0.22	-5.00
19.87	83.19	-3.86	-5.29
16.88	82.80	-6.54	-5.87
15.36	82.24	-8.07	-6.23
13.74	82.11	-9.68	-6.36
12.42	81.08	-11.00	-7.39
12.31	80.04	-11.11	-8.43
12.62	79.80	-10.80	-8.67
11.90	80.63	-11.52	-7.84
11.15	82.55	-12.27	-5.92
12.78	85.32	-10.64	-3.15
12.97	86.14	-10.45	-2.33
12.78	87.03	-10.66	-1.44
11.47	87.78	-11.95	-0.69
10.94	89.72	-12.48	1.25
9.89	92.12	-13.53	3.65
9.82	94.48	-13.60	5.99
8.41	96.56	-15.01	7.09
8.70	97.01	-16.72	8.54
12.87	98.86	-10.55	8.39

without AC device need to add -1.56 mm shift NS (for Mar9)

without AC device need to add -0.19 mm shift EW (for Mar9)

Note: Depth from top of headworks

AC device jumped out of groove at 20 ft.

(IE. data below 20 ft possibly no good)

AC device was pulled from bottom up with readings taken top to bottom resulted in problem

Correction was read from bottom to top and used a different groove

N/S +VE CHANGE TOWARDS SOUTH

E/W +VE CHANGE TOWARDS EAST

APPENDIX D

Autocentering Readings
Inverse Pendulum (19+77.5), Unit 4

(1) Summary - Absolute Position

(2) January 23 - 9 am and 3:30 pm

(3) March - 11:30 am

(4) March 7 - 1:00 pm

(5) March 9, 1:40 pm

R.H Saunders Generating Station Jan 23/91

Auto Centering Readings - Inverse Pendulums Unit 4

Depth (Ft)	1st Set 9:00 AM N/S (mm)	1st Set 9:00 AM E/W (mm)	ABSOLUTE POSITION N/S (mm)	ABSOLUTE POSITION E/W (mm)
Initial	25.03	93.78		
3	14.86	94.74	-10.17	0.96
8	11.45	93.5	-13.58	-0.28
13	7.65	94.39	-17.38	0.61
18	6.9	95.86	-18.13	2.08
23	11.56	96.89	-13.47	3.11
28	18.11	95.86	-6.92	2.08
33	24.05	94.25	-0.98	0.47
36	25.93	93.83	0.9	0.05
40	25.55	94.32	0.52	0.54

2nd Set 3:30 PM N/S (mm)	2nd Set 3:30 PM E/W (mm)	ABSOLUTE POSITION N/S (mm)	ABSOLUTE POSITION E/W (mm)
25.02	93.78		
15	94.95	-10.02	1.17
11.68	93.42	-13.34	-0.36
7.79	94.31	-17.23	0.53
6.9	95.79	-18.12	2.01
11.63	96.79	-13.39	3.01
18.03	95.84	-6.99	2.06
24.13	94.18	-0.89	0.4
26.05	93.79	1.03	0.01
25.51	94.05	0.49	0.27

NOTE: A/C device has 2 ft. leader on chain to centreline wheels

Concrete surface is bottom of gutter - 2.5 ft. below

S4 elevation (130 ft). All depthsare relative to top of NQ rods at 6 inches above the floor (130.5 ft).

The first A/C MSMT at bottom of gutter - read 1 ft. on chain.

Anchor point is at elevation 89 ft. 2 inches from top of NQ

N/S - +ve change is more north

E/W - +ve change is more west

R.H Saunders Generating Station Mar 1/91
Auto Centering Readings - Inverse Pendulums

Readings 11:30 AM Mar 1/91
unit #4 running

Depth (Ft)	N/S (mm)	E/W (mm)	ABSOLUTE POSITION N/S (mm)	E/W (mm)
Initial	24.92	93.74		
3	14.94	94.28	-9.98	0.54
8	11.57	93.07	-13.35	-0.67
13	7.75	94.2	-17.17	0.46
18	6.78	95.5	-18.14	1.76
23	11.49	96.66	-13.43	2.92
28	17.88	95.6	-7.04	1.86
33	23.9	93.96	-1.02	0.22
38	25.83	93.71	0.91	-0.03
40	25.32	93.97	0.4	0.23

NOTE: A/C device has 2 ft. leader on chain to centreline wheels
Concrete surface is bottom of gutter - 2.5 ft. below
S4 elevation (130 ft). All depthsare relative to top of NQ rods
at 6 inches above the floor (130.5 ft).
The first A/C MSMT at bottom of gutter - read 1 ft. on chain.
Anchor point is at elevation 89 ft. 2 inches from top of NQ

N/S - +ve change is more north
E/W - +ve change is more west

R.H Saunders Generating Station Mar 7/91
Auto Centering Readings - Inverse Pendulums

Readings Mar7/91 1:00 to 2:00 pm
unit #4 dewatered

N/S (mm)	E/W (mm)	ABSOLUTE POSITION N/S (mm)	E/W (mm)
24.94	93.72		
14.93	94.38	-10.01	0.66
11.42	93.35	-13.52	-0.37
7.7	94.41	-17.24	0.69
6.79	95.59	-18.15	1.87
11.41	96.81	-13.53	3.09
17.88	95.74	-7.06	2.02
23.97	94.02	-0.97	0.3
25.79	93.78	0.85	0.06
25.31	94	0.37	0.28
24.91	93.77 after		

NOTE: A/C device has 2 ft. leader on chain to centreline wheels
Concrete surface is bottom of gutter - 2.5 ft. below
S4 elevation (130 ft). All depthsare relative to top of NQ rods
at 6 inches above the floor (130.5 ft).
The first A/C MSMT at bottom of gutter - read 1 ft. on chain.
Anchor point is at elevation 89 ft. 2 inches from top of NQ

N/S - +ve change is more north
E/W - +ve change is more west

R.H Saunders Generating Station Mar 9/91
Auto Centering Readings - Inverso Pendulums

Readings Mar9/91 1:40 pm
unit #4 watered up

N/S (mm)	E/W (mm)		ABSOLUTE POSITION N/S (mm)	E/W (mm)
24.88	93.74	before		
14.85	94.44		-10.03	0.7
11.42	93.29		-13.46	-0.45
7.73	94.35		-17.15	0.61
6.71	95.53		-18.17	1.79
11.42	96.78		-13.46	3.04
17.89	95.75		-6.99	2.01
23.95	94.05		-0.93	0.31
25.89	93.75		1.01	0.01
25.45	94.1		0.57	0.36
24.86	93.75	after		

NOTE: A/C device has 2 ft. leader on chain to centreline wheels
Concrete surface is bottom of gutter - 2.5 ft. below
S4 elevation (130 ft). All depthsare relative to top of NQ rods
at 6 inches above the floor (130.5 ft).
The first A/C MSMT at bottom of gutter - read 1 ft. on chain.
Anchor point is at elevation 89 ft. 2 inches from top of NQ

N/S - +ve change is more north
E/W - +ve change is more west

APPENDIX E

Huggenberger Crack Gauges
Initial Readings

R.H. SAUNDERS GS
HUGGENBURGER CRACKGAUGES

Barrie Mackey Dec 19/90

Gauge Point	A reading	B reading	C reading	D reading
HGRS2		Not Yet Installed		
HG22N	4.0019	4.026	5.9919	6.0677
HG22N	4.0129	4.0366	6.0166	6.0171
HG22N	4.0164	4.0287	6.0566	5.9986
HG22N	4.0042	4.0147	6.0098	6.0264
HG22N	4.0017	4.0186	6.0176	5.998
HH22N6	4.0072	4.0372	5.9951	5.9915
HG44W	4.0072	4.0474	6.0497	5.9838
HG44W	3.9865	4.0403	6.026	5.9957
HG44W	4.0055	4.0096	6.0189	6.007
HG55E7	4.0056	4.0406	6.0135	6.0043
HG55E8	4.0172	4.0222	6.035	5.9846
HG66S1	4.0271	4.0116	6.0235	5.9995
HGFL29		Not Yet Installed		
HGFL30		Not Yet Installed		
HGFLS1A		Not Yet Installed		
HGFLS1B		Not Yet Installed		
HG66S1	4.0164	4.041	5.9967	6.0039
HG66S1	4.0056	4.0123	6.0428	5.9873
HG66S16		Not Yet Installed		
HG66S1	3.9953	4.0281	6.0335	5.9979
HG66S1	4.012	3.9616	5.9621	6.012
HG66S1	4.0031	4.0024	6.0008	6.0017
HG66S2	4.029	3.9934	6.0245	6.0256
HG66S2	4.0218	3.9904	6.0164	5.9942
HG66S2	4.0563	4.0621	5.9003	6.0041
HG66S2	3.9996	4.0096	6.0017	5.9992
HGSW1	3.9989	4.0384	6.0211	5.9683
HGIG24	4.0011	4.019	6.0165	6.0083
HGIG25	4.0169	4.0102	6.012	5.987
HGIG26	3.9684	4.0256	6.0098	6.0288
HGIG27		Not Yet Installed		

R.H. SAUNDERS GS
HUGGENBURGER CRACKGAUGES

Barrie Mackey Dec Jan 08/91

Gauge Point	A reading	B reading	C reading	D reading
HGRS28				
HG22N1				
HG22N2				
HG22N3				
HG22N4				
HG22N5				
HH22N6				
HG44W9				
HG44W10				
HG44W11				
HG55E7				
HG55E8				
HG66S12				
HGFL29				
HGFL30				
HGFLS1A				
HGFLS1B				
HG66S1	3.9846	4.0307	6.0148	6.0018
HG66S1	4.0073	4.021	6.0154	5.9957
HG66S1	4.0162	3.979	5.9979	5.9763
HG66S1	3.9958	4.0056	6.0318	5.9949
HG66S1	4.0267	3.9954	5.9859	5.993
HG66S1	3.9924	4.0069	6.0178	6.0104
HG66S2	4.022	3.9931	6.0018	6.0327
HG66S2	4.0305	3.9907	5.9876	6.0262
HG66S2	3.9559	3.983	6.0137	5.9788
HG66S2	4.0005	3.9921	6.0078	6.0073
HGSW1	3.9983	4.0347	6.0133	5.9676
HGIG24	3.9924	4.0187	5.9972	6.008
HGIG25	4.0168	4.0065	6.0121	5.9857
HGIG26	3.969	4.0145	6.0138	6.0155
HGIG27	4.005	3.9926	5.9835	6.0076

R.H. SAUNDERS GS
HUGGENBURGER CRACKGAUGES

Barrie Mackey Dec Jan 23/91 8:00AM

Gauge Point	A reading	B reading	C reading	D reading	
HGRS2	Omitted From This Set of Readings				
HG22N	4.0142	4.0153	6.0359	5.9894	
HG22N2		Not Accessable			
HG22N	4.0148	3.9903	5.9821	6.0124	
HG22N4		Not Accessable			
HG22N	4.0119	4.0202	5.9858	6.0292	
HH22N6	3.995	4.0308	5.9928	6.0089	
HG44W	3.9918	4.0213	6.0085	6.046	??
HG44W10		Points Knocked Off			
HG44W	3.9841	4.005	5.997	6.0133	
HG55E7		Not Accessable			
HG55E8	3.9802	4.0362	5.974	6.032	
HG66S12		Not Accessable			
HGFL29	Omitted From This Set of Readings				
HGFL30	Omitted From This Set of Readings				
HGFLS	6.023				
HGFLS	7.999				
HG66S1	4.0173	4.0376	5.9862	6.0127	
HG66S1	4.0037	4.0111	5.9889	6.0259	
HG66S16		Not Accessable			
HG66S17		Points Knocked Off			
HG66S18		Not Accessable			
HG66S1	3.9844	3.9873	6.0115	6.028	
HG66S2	4.0177	3.9918	6.0467	6.0083	
HG66S2	4.0205	3.982	6.0259	5.9971	
HG66S2	3.9485	3.9762	5.9963	6.0049	
HG66S2	3.9975	3.9814	6.0041	6.0081	
HGSW1	3.999	4.0349	5.9586	6.0337	
HGIG24	4.0146	4.0373	6.0196	5.9755	
HGIG25	4.0068	4.0064	6.037	5.9832	
HGIG26	3.9778	4.0386	6.0142	5.9925	
HGIG27	4.0155	3.9927	6.0111	5.9737	

R.H. SAUNDERS GS
HUGGENBURGER CRACKGAUGES

Barrie Mackey Dec Jan 23/91 8: 2:15PM

Gauge Point	A reading	B reading	C reading	D reading
HGRS2	Omitted From This Set of Readings			
HG22N	4.0142	4.0151	6.0061	5.9895
HG22N2		Not Accessable		
HG22N	4.0149	3.9905	5.9826	6.0127
HG22N4		Not Accessable		
HG22N	4.0122	4.0207	5.9862	6.0293
HH22N6	3.9953	4.0311	5.9931	6.009
HG44W9		Not Accessable		
HG44W10		Points Knocked Off		
HG44W	3.9845	4.0054	5.9973	6.0137
HG55E7		Not Accessable		
HG55E8	3.9803	4.0365	5.9746	6.0324
HG66S12		Not Accessable		
HGFL29	Omitted From This Set of Readings			
HGFL30	Omitted From This Set of Readings			
HGFLS	6.0213			
HGFLS	7.9966			
HG66S1	4.0177	4.0381	5.9868	6.013
HG66S1	4.004	4.0116	5.9894	6.0266
HG66S16		Not Accessable		
HG66S17		Points Knocked Off		
HG66S18		Not Accessable		
HG66S1	3.9846	3.988	6.0127	6.0261
HG66S2	4.0162	3.9885	6.0475	6.008
HG66S2	4.0209	3.9801	6.0299	5.9988
HG66S2	3.9505	5.9782	5.9924	6.0044
HG66S2	3.9968	3.9818	6.0078	6.0031
HGSW1	3.9992	4.035	5.959	6.0036
HGIG24	4.0145	4.037	6.0198	5.976
HGIG25	4.007	4.0076	6.0341	5.9851
HGIG26	3.9782	4.0381	6.0136	5.9931
HGIG27	4.0145	3.9938	6.0101	5.9746

R.H. SAUNDERS GS
HUGGENBURGER CRACKGAUGES

Barrie Mackey Dec Jan 28/91 1 10:30 AM

Gauge Point	A reading	B reading	C reading	D reading
HGRS2	Omitted From This Set of Readings			
HG22N	4.0144	4.0154	6.0365	5.9898
HG22N2		Not Accessable		
HG22N	4.0151	3.9908	5.9829	6.013
HG22N4		Not Accessable		
HG22N	4.0124	4.021	5.9866	6.0297
HH22N6	3.9957	4.0314	5.9935	6.0095
HG44W9		Not Accessable		
HG44W10		Points Knocked Off		
HG44W	3.9849	4.0059	5.9977	6.014
HG55E7		Not Accessable		
HG55E8	3.9808	4.0369	5.975	6.0327
HG66S12		Not Accessable		
HGFL29	Omitted From This Set of Readings			
HGFL30	Omitted From This Set of Readings			
HGFLS	6.0216			
HGFLS	7.9969			
HG66S1	4.0179	4.0383	5.987	6.0133
HG66S1	4.0044	4.012	5.9899	6.0268
HG66S16		To Be Moved		
HG66S17		Points Knocked Off		
HG66S18		Not Accessable		
HG66S1	3.9848	3.9884	6.0131	6.0266
HG66S2	4.0167	3.9889	6.0477	6.0083
HG66S2	4.0213	3.9806	6.0304	5.9992
HG66S2	3.9508	3.9786	5.9929	6.005
HG66S2	3.9971	3.9823	6.0081	6.0034
HGSW13				
HGIG24	4.0148	4.0373	6.0202	5.9764
HGIG25	4.0079	4.0105	6.0356	5.9863
HGIG26	3.9787	4.0386	6.014	5.9935
HGIG27	4.0151	3.9943	6.0107	5.9751